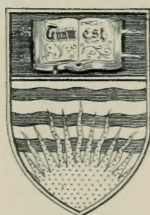


TIMBERS AND THEIR USES

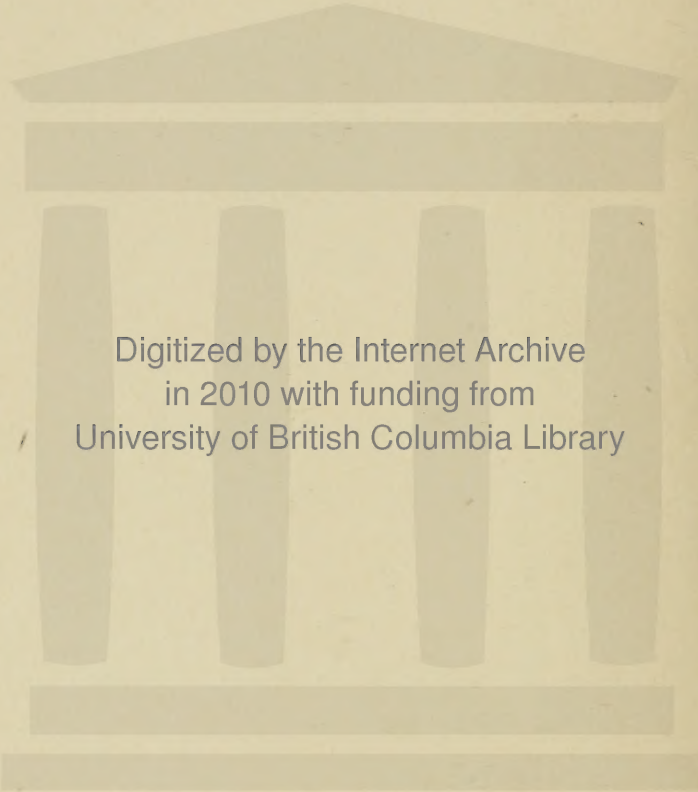
A Handbook for Woodworkers, Merchants,
and All Interested in the Conversion
and Use of Timber

WREN WINN



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A HANDBOOK FOR WOODWORKERS
MERCHANTS, AND ALL INTERESTED IN
THE CONVERSION AND USE OF TIMBER

BY

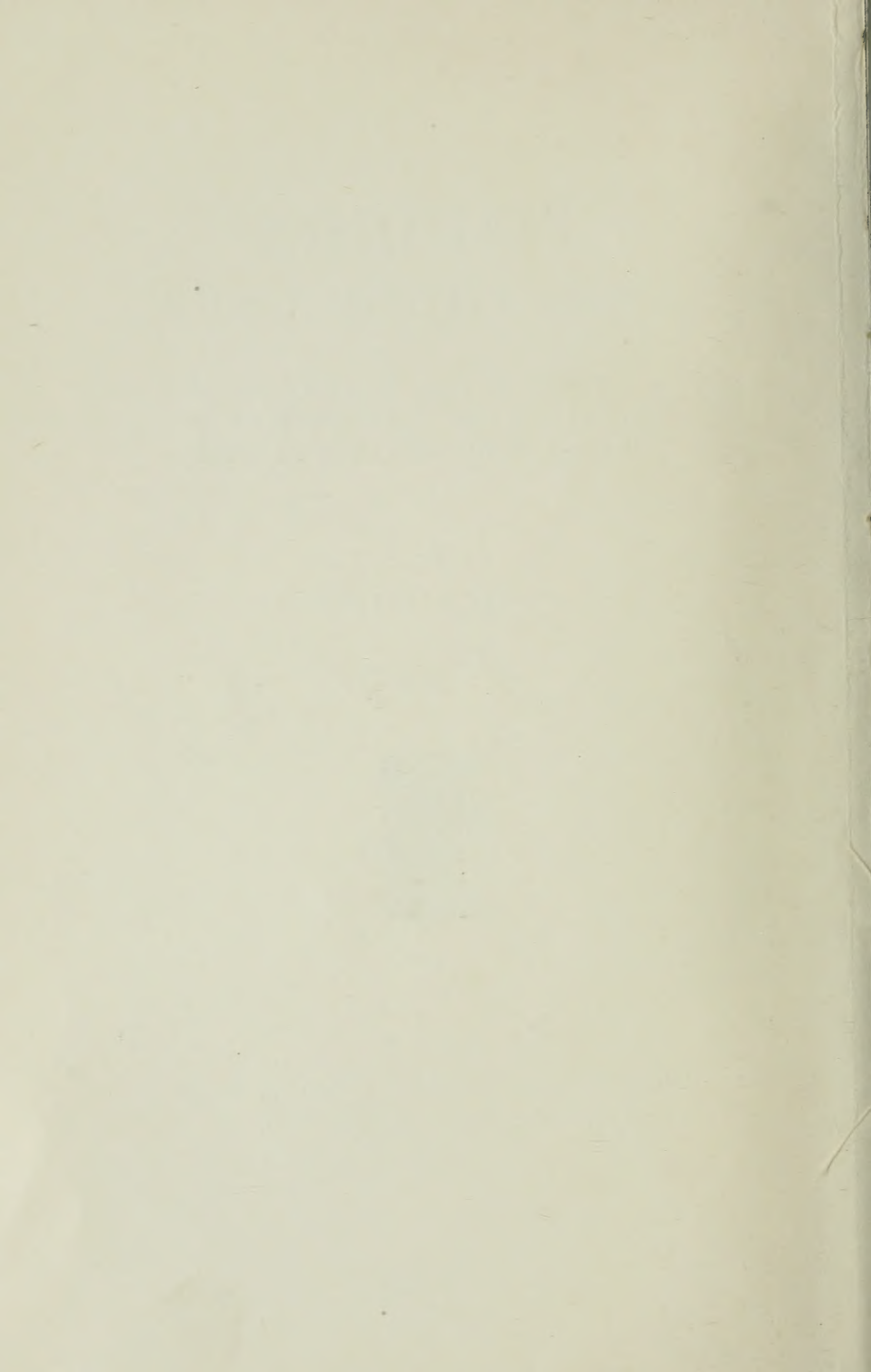
WREN WINN

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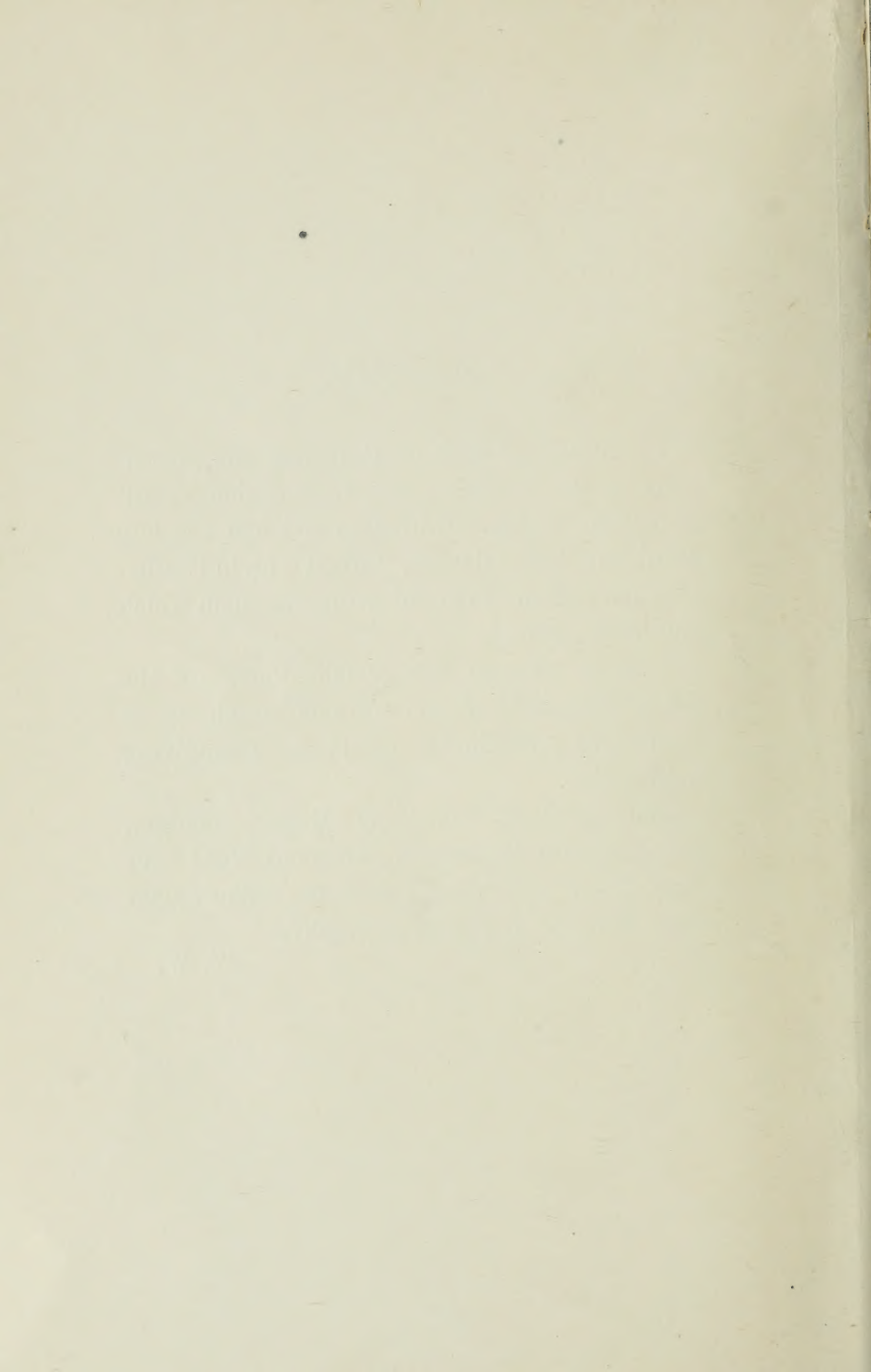
PREFACE

MY excuse for a book on timber at the present time is the pertinent one that timber is all-important to-day. Thirteen years ago the late President Roosevelt said, "Wood is an indispensable part of the material structure upon which civilization rests."

I must express my indebtedness to the Agents-General of the various provinces of Australia for invaluable assistance in supplying information.

The standard works by Messrs. Boulger, Stone, Record, Laslett, and Marshall Ward have been freely referred to, and due acknowledgment is made in the bibliography.

W. W.



CONTENTS

CHAPTER	PAGE
I. THE USES OF WOOD	1
II. GEOGRAPHICAL DISTRIBUTION	98
III. INSECT PESTS OF TIMBER	116
IV. FUNGOID PESTS OF TIMBER	139
V. ACCIDENTS DURING GROWTH	153
VI. THE WORLD'S TIMBER RESOURCES	159
VII. MANUFACTURES, ETC.	232
VIII. THE STRUCTURE AND FORMATION OF WOOD	257
IX. SEASONING OF WOOD	281
X. TIMBER TESTING	292
BIBLIOGRAPHY	307
INDEX	309



TIMBERS AND THEIR USES

CHAPTER I

THE USES OF WOOD

A MOMENT'S consideration will show how deeply indebted we are to the vegetable kingdom for many essentials and a considerable number of luxuries. We draw largely upon plants for our food ; necessary food, which we obtain from cereals, potatoes, root crops and the like ; non-essential food in the shape of luscious fruits. Fibres, of which cotton is the most important, are largely of vegetable origin. Many oils, olive, palm and the like are derived from plants. Rubber ; many gums and resins ; beverages, cocoa, tea and coffee ; medicines, quinine, belladonna and a host of others ; condiments, spices and dyes, all contribute to the grand total. By no means the least important of the vegetable products are the timbers of the world.

The use of wood by mankind is no modern innovation, it has been pressed into human service from the earliest times. " Our civiliza-

tion has been developed largely upon its possibilities." In the ages of long ago, before metal implements were known, when stone was utilized for cutting, buildings and various utensils were fashioned of wood. Boats were constructed by burning fires atop of some rough hewn log, till such time as the centre was charred and easily chipped away. With the advent of metals, wood became more easy to work and also, for certain purposes, fell into disuse. But, despite all rivals, wood, by reason of the many uses to which it may be put, continues to hold its own and not only so, but is in more demand to-day than ever before. On the score of cheapness alone, wood has a tremendous advantage over metal, it is cheaper in production, cheaper in manufacture. Even in the days when cheapness became the "golden calf" of this country, low price alone was not sufficient to establish the popularity of wood. Incredible as it may seem to one who has never made comparative strength tests between wood and metals, certain woods possess greater tensile strength than wrought iron of the same weight; show a higher compression stress than a piece of wrought iron of the same weight and height. Also, a long beam of well-seasoned wood of certain kinds shows less deflection under a load, than an iron bar of the same length and weight, under the

same load. Wood, again, has much greater powers of recovery after bending than has iron. Wood under long continued strain does not crystallize as do many metals. It does not rust. It is not affected by weak acids. The supply, under a proper system of forestry, is practically unlimited. On the other side of the account may be mentioned the fact that wood is liable to decay, that it is affected by moisture, that it cannot be melted or cast or rolled.

For ease of reference by those who are interested in the world's timbers, we have elected to arrange them under the headings of the various manufactures and trades in which they are most commonly used. To save repetition, as many timbers are used for various purposes, where it is necessary to mention a timber a second or third time the reader is referred back to the section under which the wood is first mentioned.

We may fittingly remark here that the popular or trade names of many timbers are in a state of hopeless confusion. Thus the Pines should properly be woods of the genus *Pinus*, but included under the popular name are also members of the genera *Agathis*, *Araucaria*, *Dacrydium*, *Frenela*, *Podocarpus* and *Pseudotsuga*. The Mahoganies, again, are in a hopeless case, so much so that eminent experts confess themselves unable to alleviate the chaos.

4 TIMBERS AND THEIR USES

Woods from the genera *Swietonia*, *Cedrela*, *Kaya*, *Eucalyptus*, *Cercocarpus*, *Soymida*, *Persea*, *Caesalpina*, *Betula*, *Tristania* and *Kiggelaria*, to mention a few, all masquerade under the name Mahogany. The tale could be unfolded *ad nauseam*, but no useful purpose would be served in doing so.

For the sake of convenience we have divided our timbers into twenty-six sections and in alphabetical order. The name of a timber followed by a word in brackets, indicates that the description of the timber will be found in the section mentioned within the brackets ; thus our first wood reads Acle (Piles), that is to say the description of the wood Acle will be found under the heading Piles.

Bridges. For bridge building it is essential that the wood used be strong and at the same time capable of resisting the action of water. Where the bridge may happen to be constructed in salt water, a further recommendation is the power of withstanding the attacks of Ship-Worms. Many of the timbers suitable for use as Piles may also be utilized in bridge building.

ACLE (Piles).

ANAN, *Fagraea fragrans*, occurs in Burma. It is useful for bridge building on account of its durability and because it is not destroyed by

ship-worm. It is a mottled rich brown close-grained timber.

ANJAN (Sleepers).

BULLET WOOD, ANDAMAN (Sleepers).

CURUPAY (Wheels).

GREENHEART (Piles).

GUM, RED (Piles).

HIBA, *Thuopsis dolabrata*, occurs in Japan. A very durable, white timber but its small size mitigates against its utility.

IRONWOOD, *Sideroxylon inerme*, occurs along the East Coast of Africa. A durable timber, heavy, hard and close grained, yellowish in colour mottled with chestnut.

SAL (Sleepers).

SUNDRI (Wheels).

SNEEZEWOOD, *Pteroxylon utile*, occurs in South Africa. This wood earns its popular name on account of the fact that the dust produced during its working causes sneezing and running of the eyes. It is but little affected by water and not at all by ship-worm or white ants. Very hard, heavy, durable and inflammable. Pale brown in colour, darkening on exposure. "The most valuable of South African woods and one of the most durable woods in the world."

Building. An enormous variety of woods are used for building purposes, to enumerate

them all in our pages would occupy too much space. Strength and ease of working are necessities in building timbers; added to these qualities, woods for exterior use should be little affected by the weather and those destined for indoor use should be capable of taking a good finish. Many of the timbers mentioned below are little known in this country, but their importation and use here is only a question of time.

ANGELIN, *Andira inermis*, occurs in Tropical America, Northern South America and West Indies. This is a pale red durable wood, capable of withstanding submersion in water or burial underground.

ANGELLY, *Artocarpus hirsuta*, occurs in Burma, Ceylon and South West India. A durable tough wood which stands exposure to the weather remarkably well.

ANJAN (Sleepers).

APPLE, BLACK, *Sideroxylon australe*, occurs in New South Wales and Queensland. A close grained almost canary yellow wood. It is sometimes known in Australia as the Wild Plum.

ARJUN (Masts).

ASH, VICTORIAN MOUNTAIN (Fig. 17) (Coach Building).

BAKULA, *Mimusops elengi*, occurs in India and Ceylon. A hard, durable red wood.

BANDARA (Sleepers).

BEECH, EVERGREEN (Musical Instruments).

BOIS CHAIRE (Furniture).

CANELLE; *Nectandra mollis*, occurs in Brazil.

A brown wood and easily worked but none too durable.

CANNON BALL TREE (Wheels)

CEDAR, CANOE (Cooperage).

CEDAR, GUIANA, *Icica altissima*, also called BAGASSE, occurs in British and French Guiana. A durable, easily worked wood.

CHAMPAK (Furniture).

COFFEE TREE (Fencing).

CUCUMBER TREE (Turnery).

EBONY, BOMBAY, *Diospyros ebenus*, occurs in India, Burma, Straits Settlements and Malay Archipelago. A very hard, heavy wood. In colour black striped with brown, sapwood much paler in colour.

GRANADILLO (Furniture).

GUM, CABBAGE (Furniture).

GUM, MOUNTAIN (Sleepers).

GUM, NANKEEN (Sleepers).

GUM, SLATY (Sleepers).

HARRA (Dyes).

HEMLOCK SPRUCE (Sleepers).

HIBA (Bridges).

IROKO (Sleepers).

IRONBARK, WHITE (Fig. 12) (Furniture).

IRONWOOD, BORNEO (Piles).

JACK (Musical Instruments).

JAMBOLANA (Sleepers).

JARUL (Shipbuilding).

JHAND (Wheels).

JUNIPER, AUSTRALIAN (Inlaying).

KAURI (Fig. 42) (Sleepers).

KAYA (Cabinet making).

LEATHER JACKET (Wheels).

MAHWA (Wheels).

MESQUITE (Furniture).

MOLAVÉ, *Vitex altissima*, occurs in the Philippines. A pale yellow, durable, close-grained wood capable of withstanding exposure without warping or decaying. A very useful wood for building purposes.

NOGAL (Furniture).

PACARA (Furniture).

PADER (Furniture).

PINE, NORTHERN, *Pinus sylvestris* (Fig. 43), also known as Scots Fir, Danzig Fir, Baltic Fir, White Sea Fir, Swedish Fir, Norway Fir, Redwood, Red Deal, Yellow Deal. Occurs in Northern Europe, Asia and America. This is a very valuable wood, in general the farther north the habitat of the tree the better the quality of its timber. It is a resinous wood, yellowish and brownish red in colour. A tough,

THE USES OF WOOD

elastic and easily worked wood, durable in water and in the ground.

PINE, OREGON (Figs. 47, 48) (Masts).

PINE, WHITE, *Pinus strobus* (Fig. 44), also known as the Weymouth and Yellow Pine. occurs in North America and Newfoundland and as an introduced species, in England. It produces timber of very variable quality but, generally, it is light, clean, straight grained and easily worked. It is not durable in the ground.

PURPLEHEART (Furniture).

SIRIS, PINK (Furniture).

SPRUCE, SITKA (Charcoal).

STINKWOOD, *Ocotea bullata*, also known as Cape Walnut, Cannibal Stinkwood, Cape Laurel, Laurel Wood, Bean Trefoil, occurs in South Africa. A dark walnut coloured timber, often almost black and invariably mottled, very strong, tough and durable.

TEAK, BASTARD, *Pterocarpus marsupium* occurs in Central and Southern India. The heartwood is red, sapwood white. It is hard, easily polished and durable except in contact with water.

THUYA, *Thuya articulata*, occurs in Northern Africa. This wood is "the 'Lignum Vitae' of the French, the 'Alerce' of the roof of Cordova Cathedral, and probably the 'Citron wood' of the Romans, for tables made of which wood

thousands of pounds were paid, and the ‘Thyine wood’ of the Apocalypse.”

TULIP TREE, *Liriodendron tulipifera* (Fig. 16), also known as Canary Whitewood, Whitewood, Canadian Whitewood, Poplar, Yellow Poplar, Virginian Poplar, Saddle Tree, Yellow wood, Canoe wood. Occurs in North America and Canada. In colour it varies from yellowish white to grey. It is a soft, easily worked, none too durable wood taking a fair polish, but warping badly in seasoning.

WALNUT, EAST INDIAN, *Albizzia Lebbek*, also known as the Siris tree and Cotton varay. Occurs in India and Tropical Africa. A walnut-coloured, coarse, open-grained, tough hard wood, durable and easily worked and polished. “Immune to dry rot.”

Cabinet Making. The timber for the cabinet maker should be easily worked yet strong; reasonably durable, with appearance a secondary consideration.

AILANTHUS (Charcoal).

ASH, AMERICAN (Furniture).

ASH, BLUEBERRY, *Elaeocarpus cyaneus* (Fig. 63), also known as Native Olive and White Boree. Occurs in Eastern Australia and Tasmania. A tough wood with dark-coloured heartwood and white sapwood.

BAGASSE, a synonym for Guiana Cedar (Building).

BALLY GUM (Flooring).

BASSWOOD (Cooperage).

BEEFWOOD (Furniture).

CAMPHOR, NEPAL, *Cinnamomum glanduliferum*, also known as Nepal or Assam Sassafras. Occurs in India. A strong wood, brown in colour and very durable.

CANARY WOOD, INDIAN (Dyes).

CANELLE (Building).

CEDAR, ATLAS (Sleepers).

CEDAR, BASTARD PENCIL, *Dysoxylum rufum*, occurs in Queensland and New South Wales. An easily worked wood, of the usual cedar red colour.

CEDAR, CAPE RED (Wheels).

CHERRY, WILD BLACK, *Prunus serotina*, also known as American Cherry, Black Cherry. Occurs in Canada and North America. A fine open-grained wood of a dark red colour with yellowish sapwood. Durable and easily polished. Useful for interior work.

CHESTNUT (Charcoal).

COACH WOOD (Coach building).

COCOWOOD (Carving).

COTTONWOOD, *Populus monilifera*, also known as Lacewood, Necklace Poplar, Carolina Poplar, Poplar, Big Cottonwood, occurs in

12 TIMBERS AND THEIR USES

Canada and United States. A fine, open-grained wood, lustrous and silky, easy to work but liable to warp. Yellowish white in colour.

CYPRE, BOIS DE, *Cordia gerascanthus*, also known as Spanish Elm, Prince wood, Dominica Rosewood, Claraiba, Bois de Roses, Bois de Rhodes. Occurs in Tropical America and Jamaica. "Hath a very sweet, pleasant smell almost like a rose." A soft, coarse open-grained wood, brown in colour and very durable. "One of the best timber woods of Jamaica."

CYPRESS PINE, MOUNTAIN, *Frenela parlatoresi*, also known as Stringy-bark Pine. Occurs in Australia. A cream-coloured, soft, close-grained wood. Easily worked.

EBONY, CUBAN, *Diospyros tetrasperma*. A hard, black wood.

ELM, SPREADING (Turnery).

FIR, GREAT (Cooperage).

HOBOOBALLI, *Stryphnodendron guianense*, occurs in British Guiana. A fine, open grained wood. The heartwood is pale brown marked with darker brown concentric bands. A beautiful wood, capable of taking a high polish. One of the most durable of all woods in contact with water.

HORSE CHESTNUT (Fig. 60) (Flooring).

IRONWOOD, AUSTRALIAN, *Acacia excelsa*, occurs in Queensland. A hard, close-grained wood, possessed of a scent of violets.

JACK, LONG (Shipbuilding).

JUNIPER, AUSTRALIAN (Inlaying).

KAMASSI (Engraving).

KAYA, *Torreya nucifera* (Fig. 73), occurs in Japan. A pale yellow, straight-grained, hard wood.

KIAMIL (Wheels).

KOHE KOHE, *Dysoxylum spectabile*, also known as Redheart. Occurs in New Zealand. A very fine-grained wood with a rose-red heart and a brown sap. Soft and easily worked.

LARCH (Wheels).

MAPLE (Charcoal).

LOCUST (Fig. 23) (Wheels).

LOCUST, BLACK (Fig. 23) (Wheels).

MAGNOLIA, LARGE FLOWERED, *Magnolia grandiflora*, also called Bull Bay and Big Laurel. Occurs in Southern United States. Though heavy this wood is weak and soft; it is white in colour.

MIVA, *Lucuma galastoxylon* (Fig. 19), also known as Pencil Cedar, Cairn's Cedar, Cairn's Pencil Cedar. Occurs in Queensland, a close-grained red wood, easily worked.

MOLAVÉ (Building).

MUSK WOOD (Fig. 64) (Turnery).

PANACOCO, *Robinia panacoco*, occurs in French

14 TIMBERS AND THEIR USES

Guiana. A hard durable timber with black heartwood.

PEAR (Turnery).

PINE, BLACK (Piles).

PINE, DUNDATHA, *Agathis robusta*, also called Queensland Kauri, occurs in Queensland. An easily worked timber which, though close grained, is soft. Pale yellow in colour.

PINE, LONG LEAF (Medicine).

PINE, MORETON BAY, *Araucaria Cunninghamii* (Fig. 41), also known as Hoop Pine. Occurs in Queensland and New Guinea. A hard, strong, easily worked wood of a pale colour. Fairly durable.

PINE, NORTHERN (Fig. 43) (Building).

PINE, SUGAR (Cooperage).

PLANE, EASTERN, *Platanus orientalis*, also known as Lacewood. Maple-leaved Plane tree, occurs in the Mediterranean region and Europe generally. This is a fine but open-grained timber, easily polished but not very durable. The sapwood is pinkish in colour and the heartwood yellowish, reddish or brownish according to age, the old wood is not unlike Walnut in appearance.

PLUM (Musical Instruments).

PLUM, SOUR, *Owenia venosa*, also known as Tulip wood, occurs in Queensland. A very hard,

strong and durable wood, beautifully marked, easily worked and polished.

QUEENWOOD, *Daviesia arborea*, occurs in Queensland. A close-grained hard and easily polished timber.

REDWOOD, CALIFORNIAN, *Sequoia sempervirens*, also known as Giant Redwood, occurs in California. "The softest timber wood of commerce." A light soft wood, very durable in the soil, inclined to be brittle. "The wood is so soft and porous that it dries quickly, losing its vitality entirely. Being thus absolutely dead wood, it keeps its shape in spite of all exposure, and is probably the most reliable known wood for such a purpose as a jointed sign-board exposed to the elements. The joints of such a board, if made of Redwood, once dry, will never open." The heartwood is a rich red, sapwood nearly white.

REWA-REWA (Inlaying).

RIMU, *Dacrydium cupressinum*, also known as New Zealand Red Pine, occurs in New Zealand. A fine straight-grained timber durable in the soil. "It works like English Birch, saws and planes easily and sweetly, but the grain 'picks up' in little scales. Closely resembles Satin Walnut and is the most widely used timber of cabinet work in New Zealand."

16 TIMBERS AND THEIR USES

ROSEWOOD, BRAZILIAN (Musical Instruments).

SANDERS WOOD, RED (Fig. 69) (Dyes).

SATINWOOD (Furniture).

SNEEZEWOOD (Bridges).

TARCO, *Thouinia Weinmannifolia*, also known as White Ebony, occurs in Argentina. A white wood of ivory-like appearance.

TULIP WOOD (Engraving).

TUPELO, *Nyssa uniflora*, also known as Cotton Gum, Black Gum, Sour Gum, Yellow Gum and Tupelo Gum, occurs in Southern United States. A cross-grained, heavy tough wood; easily worked but liable to warp. Sapwood pale yellow, heartwood pale brown.

TURNIP WOOD, *Synoum glandulosum*, also known as Bastard Rosewood, Brush Bloodwood, Dogwood, occurs in Queensland and New South Wales. A wood of peculiar odour; the bark has a smell which is strongly reminiscent of turnips; the wood when fresh cut smells of roses, an odour which gives place to that of Cedar on exposure to the air. An easily worked and polished wood.

WACAPOU (Sleepers).

WALNUT, AMERICAN, *Juglans nigra* (Fig. 54), also known as Black Walnut, Waney Black Walnut, occurs in North America and Canada. An open-grained dull-surfaced wood; easily

worked and polished ; durable in the soil ; very tough and strong. At one time this wood was not held in much esteem, but is now more used than European walnut. The heartwood is very dark brown, almost black, with occasional purple tinges.

WILLOW, CRACK, *Salix fragilis*, also known as Stag's Head Osier, Withy, Bedford, Redwood Willow, occurs in Europe, North and West Asia. A tough elastic wood and the best of the Willows for cabinet making.

Coach and Carriage Building. Timbers used in Coach, Carriage and Waggon building should be light yet tough with considerable elasticity, for they are subject to considerable shocks and strains.

ACACIA, *Eucryphia Moorei*, also known as White Sally, Plum and Acacia Plum, occurs in New South Wales and Victoria. A hard, easily worked brown wood.

ACLE (Piles).

AKAGASHI, *Quercus acuta*, occurs in South Japan. A rich brown tough wood.

ALMOND, WILD (Turnery).

ASH, AMERICAN (Furniture).

ASH, BLUE, *Fraxinus quadrangulata*, occurs in Central United States. The strongest and most durable of all the Ashes.

ASH, CAPE, *Ekebergia capensis*, occurs in South Africa. A tough, close-grained wood.

ASH, OREGON, *Fraxinus oregona*, occurs in Western United States. Not unlike American Ash (*F. americana*), liable to be brittle.

ASSEGAI WOOD, *Curtisia faginea*, also known as Cape Lancewood, Hassagay wood, Beech-leaved Assagay-boom, occurs in South Africa. A timber of very fine, close, even grain. Tough and elastic, very durable. Works well and takes a good polish. Durable, a rich red colour.

BEECH, CAPE, *Myrsine melanophleos*, occurs in South Africa. A very dense, fine-grained wood. Works well and neither cracks nor warps. Brownish in colour with a reddish silver grain.

BIRCH, CHERRY, *Betula lenta*, also known as American Birch, Black Birch, Mahogany Birch, Mountain Mahogany, Sweet Birch, Yellow Birch, River Birch, Mountain Birch, occurs in the United States and Canada. A close, even-grained wood, very strong and taking a good polish. Often stained to imitate Mahogany. Heartwood red-brown, sapwood yellowish. Often beautifully figured.

BLACKBUTT (Fig. 6) (Wheels).

BLACKWOOD (Figs. 7-10) (Musical instruments).

CAJEPUT, *Melaleuca leucadendron*, also known

as White Tea Tree, Paper-bark Tree, Paper-barked Tea Tree, Swamp Tea Tree, Milkwood Tree, occurs in Australia. When worked this timber smells like Brazil nuts. A close-grained, hard and durable wood. Brownish red in colour.

COACH WOOD, *Ceratopetalum apetalum*, also known as Leather Jacket, Light Wood, occurs in New South Wales. A light close-grained, tough, elastic wood.

ELM, CANADIAN (Fig. 52), *Ulmus racemosa*, also known as Cliff Elm, White Elm, Rock Elm, Hickory Elm, Cork Elm, American Elm, Swamp Elm, occurs in the United States and Canada. A fine close-grained timber which, to the touch, resembles cane. A very elastic yet strong wood. Durable. "Bears nails better than any other timber." Bends easily. Heartwood light brown, sapwood yellowish.

ELM, ENGLISH, *Ulmus campestris*, also known as Common Elm, Cork Elm, European Elm, occurs in Europe generally. "The Rialto at Venice is said to be built on 12,000 Elm piles." A coarse, open-grained wood, liable to shrinkage and warping, but durable. Heartwood reddish brown, sapwood yellow.

GUM, BLUE, *Eucalyptus globulus* (Fig. 1), also known as Grey Gum, Bastard Box, occurs

20 TIMBERS AND THEIR USES

in Victoria and South Tasmania, introduced into South Europe, North Africa, North America, India and South Africa. "Smells like acetic acid during working." A fine, open-grained timber, tough, elastic and fairly easily worked. Liable to warp. Heartwood brownish or pinkish, sapwood pinkish.

GUM, BROAD-LEAVED (Piles).

GUM, SCRIBBLY, *Eucalyptus Laemastoma* (Fig. 2), also known as Blue Gum, Blackbutt, Mountain Ash, Spotted Gum, White Gum, Gum Top Stringy-bark, occurs in Australia. A brittle, easily worked, none too durable wood.

HICKORY (Wheels).

JAMBOLANA (Sleepers).

JARUL (Shipbuilding).

JHAND (Wheels).

KARRI (Wheels).

MAHOGANY, BASTARD (Paving).

MANGOSTEEN, FALSE, *Sandoricum indicum*, also known as Wild Mangosteen, Indian Sandal-wood, occurs in Burma, Southern India, Philippines, Moluccas. A very dense, easily polished wood. Heartwood rich brown, sapwood white.

MARGOSA (Furniture).

MYRTLE, WHITE, *Myrtus acmenioides*, occurs in North Eastern Australia. A close-grained durable, tough timber,

OAK, CALIFORNIAN LIVE, *Quercus chrysolepis*, also known as Valparaiso Oak, Maul Oak.

OAK, INDIAN (Shipbuilding).

OAK, THICK CUP LIVE. Occurs in Western United States. A hard, tough close-grained timber.

OSAGE, ORANGE (Paving).

POPLAR, BLACK (Pulp).

SAFFRON WOOD (Furniture).

SAJ (Paving).

STINKWOOD (Building).

TEAK, BASTARD (Building).

TULIP TREE (Fig. 16) (Building).

Carving. Timbers used for this purpose should be of such a nature that they may be easily worked, not liable to split and more or less ornamental.

CEDAR, MOULMEIN (Furniture).

CHITTAGONG WOOD, *Chukrasia tabularis*, also known as Cedar, Bastard Cedar and Deodar, occurs in India. A hard but easily worked, rich brown wood possessed of a beautiful lustre. Inclined to warp.

COCO WOOD, *Bocoa pruvacensis*, also known as Boco, occurs in British Guiana. An ornamental timber with nearly black heartwood and yellow sapwood. Easily worked.

EBONY, BOMBAY (Building).

ELS (Musical Instruments).

LASPIN (Wheels).

ROWAN, *Pyrus aucuparia*, also Mountain Ash, Fowler's Service Tree, Quicken Tree, occurs in Europe, North America, Northern and Western Asia, Madeira. A dense, fine-grained timber, not easily split. Takes a high polish and works well. Heartwood reddish brown, sapwood cream-coloured.

Charcoal. As the destructive distillation of wood and the production of Charcoal is dealt with elsewhere, we need not here enter into a discussion concerning the most useful woods for charcoal production.

ALDER. *Alnus glutinosa* (Fig. 24), also known as Common Alder, Black Alder, occurs in Europe. A very fine grained timber, light and soft and very durable under water. "The piles of Ravenna, according to Vitruvius, and those of the Rialto at Venice, and those of Amsterdam, according to Evelyn, were largely of Alder, and Pliny speaks of it as 'eternal' when so used." It is considered by many to be the best wood for gunpowder charcoal.

BASSWOOD (Cooperage).

BEECH, *Fagus sylvatica* (Fig. 56), also known as White Beech, St. John's Beech, American

Beech, occurs in Europe, North America and Asia Minor. A fine, close-grained, light-surfaced timber. Durable under water or underground ; a piece of this wood “ became as hard as stone after being buried for twenty-four years.” Liable to warp. Reddish white in colour and, like Alder, a sapwood tree. Yields excellent gunpowder charcoal.

BIRCH, *Betula alba*, also known as Common Birch, European Birch, Silver Birch, Russian Maple, Russian Birch, occurs in Northern Europe, Asia and North America. A fine, close-grained, lustrous timber. The bark is put to a number of uses, especially in North Eastern Europe. Reddish white in colour and, like Alder and Beech, a sapwood tree. Yields excellent charcoal for artists’ use.

BUCKTHORN, ALDER, *Rhamnus frangula*, also known as Black Dogwood, Berry-bearing Alder, occurs in Europe, North Africa and Siberia. A shrub which provides excellent charcoal for the manufacture of sporting gunpowder.

CASHEW-NUT, *Anacardium occidentale*, occurs almost universally in the Tropics. A hard, red wood.

CHESTNUT, *Castanea vulgaris*, also known as Spanish Chestnut, Sweet Chestnut, Edible Chestnut, American Chestnut, occurs in Europe and North America. A coarse, open-grained, moder-

24 TIMBERS AND THEIR USES

ately lustrous timber. Not strong, liable to shakes, warping and insect attack. Heartwood dark brown, sapwood white.

CHIR, *Pinus longifolia*, occurs in India. Practically useless as a timber tree, but excellent for charcoal.

DOGWOOD, *Cornus sanguinea*, also known as Prickwood, Cornel, occurs in Europe and Northern and Western Asia. Useless as timber on account of its small size. Provides good gunpowder charcoal.

FIR, SILVER (Pulp).

GUM, CIDER, *Eucalyptus Gunnii*, also known as White Gum, Yellow Gum, Sugar Gum, Swamp Gum, Bastard Gum, occurs in Southern Australia and Tasmania. A tough, dense wood of a rich brown colour.

GUM, RED (Piles).

HICKORY (Wheels).

JARRAH (Paving).

LAUREL, MADRONA, *Arbutus Menziesii*, also known as Madrona, Madrona Madera, Strawberry Tree, occurs in United States, Canada and Mexico. A fine, dense, even-grained, bright-surfaced timber. Tough, but often badly grown and liable to insect attack. Provides good gunpowder charcoal.

LIME (Fig. 15) (Musical Instruments).

MAPLE, *Acer campestre* (Fig. 57), also known as

Common Maple, Field Maple, occurs in England, Central Europe and Northern Asia. A fine-grained, hard, lustrous timber which produces the very best charcoal.

MAPLE, ASH-LEAVED (Pulp).

OAK, BROWN, *Quercus semicarpifolia*, occurs in Western Asia. A very hard wood, providing useful charcoal.

OAK, KERMES, *Quercus coccifera*, occurs in the Mediterranean region. A hard, heavy wood.

OAK, TURKEY, *Quercus cerris*, also known as Mossy-cupped Oak, Adriatic Oak, Levant Oak, Iron Oak, Wainscot Oak, occurs in Central and Southern Europe and in South West Asia. A beautifully grained timber which polishes well. This timber "has a bad reputation and is carefully avoided by the carpenter and wheelwright."

PINE, CLUSTER (Medicine).

PINE, HICKORY, *Pinus pungens*, also known as Table Mountain Pine, occurs in the Alleghany Mountains. An almost useless, soft, coarse-grained timber producing good charcoal.

PINE, LONG LEAF (Medicine).

PINE, PITCH, *Pinus rigida*, occurs in United States and Canada. A soft, brittle wood, useful for its charcoal.

SPINDLE TREE, *Euonymus europaeus*, occurs in Europe, North Africa and North Western

Asia. A hard, fine-grained, easily worked and polished wood. Its charcoal is excellent for artists and for gunpowder.

SPRUCE, *Picea excelsa*, also known as Common Spruce, Norway Spruce, Russian Spruce, White Deal, Spruce Fir, White Fir, occurs in North and Central Europe. A timber which varies considerably according to the soil on which it has grown. Whitish to reddish in colour. A tough, elastic wood, very durable and easy to work though often plentifully studded with hard knots.

SPRUCE, RED (Pulp).

SPRUCE, SITKA, *Picea sitchensis*, also known as Menzies Spruce, Tide-land Spruce, Californian Coast Spruce, Black Spruce, Silk Spruce, occurs in Western United States and Canada. A fine straight-grained, satiny-surfaced timber. "Said to be the best of the American Spruces."

TAMARIND, *Tamarindus indica*, grows universally in the Tropics. A durable, hard, not easily worked timber.

TREE OF HEAVEN, *Ailanthus glandulosa*, also known as Ailanthus, occurs in Japan and Northern China, but has been introduced into this country and the United States. A beautifully grained, hard, fairly heavy timber which takes a good polish.

WILLOW, BLACK, *Salix nigra*, occurs in North

America. Merely a shrub with soft, light, close-grained wood.

WILLOW, YELLOW, *Salix vitellina*, also known as Golden Osier, occurs in Europe. The timber is soft but strong and easily worked and polished.

Cogs. Wood used for cogs may be said to be similar to that required by the wood turner. It must be hard, tough and capable of taking a high polish if necessary.

BEECH (Fig. 56) (Charcoal).

BEECH, EVERGREEN (Musical Instruments).

BOX, RED (Shipbuilding).

BOX, YELLOW (Engraving).

CANARY WOOD (Sleepers).

COGWOOD, *Ceanothus chloroxylon*, also known as Jamaica Cogwood, Cerillo, occurs in the West Indies. A very fine, close, even-grained wood ; elastic, heavy and durable. Deep nut brown in colour.

DOGWOOD (Engraving).

GUM, SLATY (Sleepers).

GUM, WATER, *Tristania neriifolia*, occurs in New South Wales. A close-grained, elastic wood.

HORNBEAM, *Carpinus betulus*, also known as Carpy, Hardbeam, Quick Tree, Quickbeam ; the origin of the name of this tree is explained by Gerard who wrote in his *Herbal* : "The wood in

time waxeth so hard that the toughness and hardness of it may rather be compared to horn than unto wood, and therefore it was called hornbeam or hard beam." The tree occurs in Europe and Western Asia. It is a fine, dense open-grained timber, greyish white in colour, remarkable for its strength and toughness. An excellent fuel timber.

KOWHAI, *Sophora tetraptera*, occurs in New Zealand. A fine-grained, tough hard wood with a brownish heartwood and a paler sapwood.

LIGNUM VITAE, *Ixora ferrea* (Fig. 62), also known as Hackia, Iron tree, Ironwood, West Indian Ironwood, Martinique Ironwood, occurs in British Guiana and West Indies. A coarse, open-grained lustrous timber. Almost unbreakable. Difficult to plane for "it contains much grit which is bad for the cutting edge of tools." In colour it shows zones of dark and light brown.

LOCUST (Fig. 23) (Furniture).

PEAR, RED, *Scolopia Mundtii*, also known as Thorn, Thorn Pear, Wolf Pear, Klipdoorn, occurs in South Africa. A fine, open-grained timber. Very durable and tough. Reddish brown in colour.

SAL (Sleepers).

SALIEWOOD (Engraving).

SERVICE (Engraving).

WANDOO (Sleepers).

Cooperage. Woods for this purpose, whether for use as barrels to contain dry goods, or for casks to contain liquids, or for tubs and pails, all require stiff elastic woods which are not liable to warp in contact with liquids.

ASH, OREGON, *Fraxinus oregona*, occurs in North Western United States. A heavy, white wood inclined to be brittle.

ASPEN (Pulp).

BASSWOOD, *Tilia americana*, also known as Lime Tree, Willow, Linden, Lin, Bee Tree, occurs in Canada and the United States. A fine even-grained lustrous timber. Cream coloured and easily worked. Durable.

BEECH, SHE, *Cryptocarya glaucescens*, also known as White Laurel, Sassafras, Black Beech, occurs in Queensland. A soft non-durable wood.

BIRCH. (Charcoal).

BLACKWOOD (Figs. 7-10) (Musical Instruments).

CEDAR, CANOE, *Thuya gigantea*, also known as Western White Cedar, Canadian Red Cedar, Giant Arbor Vitae, Red Cedar, Yellow Cedar, Arbor Vitae, Pacific Arbor Vitae, North Western Red Cedar, Shingle Wood, Giant Cedar, Lobb's Arbor Vitae, Red Cypress, occurs in United States and Canada. A close, even-grained wood. Very durable despite its softness, easily worked. Reddish brown with a white sapwood.

CEDAR, WHITE (Sleepers).

30 TIMBERS AND THEIR USES

CEDAR, YELLOW (Sleepers).

ELM, AMERICAN *Ulmus americana* (Fig. 51), also known as White Elm, Water Elm, Swamp Elm, Canada Elm, Red Elm, Nova Scotia Elm, occurs in the United States and Canada. A fine open-grained wood with a dull surface, tough and strong, but not durable and inclined to warp. Heartwood light brown, sapwood yellowish white.

FIR, GREAT, *Abies grandis*, also known as Western White Fir, Tall Silver Fir, Great Silver Fir, Balsam, Balsam Fir, occurs in North Western United States. A fine even-grained timber, with a peculiar lustre, a strong wood. Brownish white in colour.

MAPLE, ASH-LEAVED (Pulp).

OAK, BASKET, *Quercus Michauxii*, also known as Swamp Chestnut Oak, Cow Oak, occurs in South Eastern United States. A heavy, hard, very strong and durable wood of a pale brown colour with white sapwood.

OAK, ZEEN, *Quercus Mibeckii*, occurs in North West Africa. A close-grained, heavy durable wood, tough, liable to warp. Yellowish in colour.

PINE, SUGAR, *Pinus Lambertiana* (Fig. 39), also known as Great Sugar Pine, North Carolina Pine, Columbian Pine, White-barked Pine, White Pine, Soft Pine, Pumpkin Pine, occurs in United

States and British Columbia. A coarse-grained, dull-surfaced wood. Light and soft but does not warp. Yellowish coloured. The tallest of the Pines.

PLANE, WESTERN, *Platanus occidentalis*, also known as Occidental Plane, Button wood, Butterball, Butterwood, Plane, American Plane, Plataan, Californian Buttonwood, Sycamore, Water Beech, Lacewood, Honeysuckle wood, occurs in Eastern United States and Southern Canada. A compact open-grained wood. Not easily split, liable to warp. Brownish heartwood, yellowish sapwood.

Dyes. It is hardly necessary to state that timbers which are used in the dyeing industry must be such as contain some principle which is easily extracted by chemical means and is capable of imparting a colour to substances with which it is brought into contact.

BIRCH (Charcoal).

BRAZIL WOOD (Musical Instruments).

CAMWOOD, *Baphia nitida*, also known as Caban, Barwood, Red Rosewood, occurs in West Africa. A coarse-grained dense wood with a bright surface. Reddish orange in colour. "Used by native women for rubbing on their bodies to check perspiration." Produces a red dye.

CANARY WOOD, *Morinda citrifolia*, also known as Leichhardt's Tree, Indian Mulberry, Brimstone Tree, occurs in West Africa, India and the East. A soft, yellow, easily worked wood, producing a yellow dye.

FUSTIC, *Chlorophora tinctoria*, also known as Fustick wood, Orange wood, Dyer's Mulberry, occurs in Tropical America and West Indies. An open-grained, lustrous wood of a greenish yellow colour, producing green and yellow dyes.

GAMBOGE, *Garcinia Hanburyi*, occurs in Southern Asia. A shrub, useless as a timber, but producing a valuable yellow dye.

HARRA, *Terminalia Chebula*, occurs in Burma, India and Ceylon. A hard, strong, close-grained wood, easily polished but liable to insect attack. The fruits, known as Black Myrobalans, are used in dyeing.

INDIGO, *Indigofera tinctoria*, occurs in India. A shrub from which blue dyes are extracted.

JACK (Musical Instruments).

LOGWOOD, *Haematoxylon campechianum*, also known as Mahogany, though wrongly so named, Campeachy wood, occurs in West Indies, Central America and Brazil. A coarse-grained wood of a mahogany-red colour. Gives valuable purple, blue and black dyes and is used in the production of ink.

OAK, YELLOW, *Quercus tinctoria*, also known

as Black Oak, Quercitron Oak, occurs in Eastern United States. A strong, heavy, coarse-grained wood from which a yellow dye is obtained. The bark is used in tanning.

SANDERS WOOD, RED, *Pterocarpus santalinus* (Fig. 69), also known as Red Sandalwood, occurs in Ceylon, Burma, China, Java. A very hard, heavy, fine-grained wood, producing a red dye.

SAPPAN WOOD, *Caesalpina sappan*, also known as Bukkum wood, Narrow-leaved Braziletto, Brazil Redwood, occurs in South India, Burma, Siam and the Philippines. A coarse-grained, dense lustrous wood, of a deep orange-red colour. Produces red and violet dyes, whilst an orange dye is extracted from the roots.

YENJU, *Sophora japonica*, occurs in China and Japan. A fine-grained hard wood from which green and yellow dyes are obtained.

Engraving. Wood for wood engravers' blocks must be hard, yet capable of being easily worked without splitting or tearing ; a fine grain is also an essential.

BEECH (Fig. 56) (Charcoal).

BOX, *Buxus sempervirens* (Fig. 61), also known as English, Abassia, Anatolian, Circassian, Corsican, Partheni, Persian and Turkish Box, occurs in Europe and Asia. A very fine, close-grained, dense wood, with a smooth and somewhat

lustrous surface. "Splits with great difficulty and takes a natural polish." Yellowish or brownish in colour and a sapwood tree. "For the most delicate articles, the wood is soaked for twenty-four hours in fresh very clean water, then boiled for some time. When taken out of the boiling water, it is wiped perfectly dry and buried, till wanted for use, in sand or bran." Used since the fifteenth century for wood engraving, the best wood for scientific instruments.

BOX, YELLOW, *Eucalyptus melliodora* (Fig. 5), also known as Red Gum, Yellow Jacket, Honey-scented Gum, occurs in Eastern Australia. A hard, heavy close-grained timber, very durable and tough. Yellow in colour.

CEDAR, AUSTRALIAN PENCIL, *Dysoxylum Fraserianum* (Fig. 18), also known as Australian Mahogany, Bog Onion, Rosewood. An open-grained wood which is said to be used for wood engraving, but Bailey's reference to its use for backing electros is probably more correct. Its open grain renders it unsuitable for engraving upon. Light red in colour.

DOGWOOD, AMERICAN, *Cornus florida*, also known as Cornel, Flowering Dogwood, Boxwood, Cornelian wood, Western Dogwood, occurs in United States. A very fine, close-grained, lustrous timber. Very heavy, hard and strong. Brownish in colour.

GUM, GIMLET, *Eucalyptus salubris*, also known as Fluted Gum, occurs in Western Australia. A tough, easily worked, dark brown wood.

HAWTHORN, *Crataegus oxacantha*, also known as May, Whitethorn, occurs in Europe, North Africa, North and West Asia. A heavy, hard, close-grained wood and the best of all substitutes for box for engraving.

IVORYWOOD, *Siphonodon australe*, occurs in Queensland. Very close-grained, though easily worked, white wood.

KAMASSI, *Gonioma Kamassi*, also known as East London Boxwood, Cape Boxwood, Knysna Boxwood, occurs in South Africa. A very fine-grained wood, of a uniform yellow colour.

PAI CHA, *Euonymus europaeus*, var. *Hamiltonianus*, occurs in China. A very hard, fine, close-grained wood, a good substitute for box.

SALIEWOOD, *Buddelia salvifolia*, also known as Saliehout, occurs in South Africa. A fine compact wood. Very tough, reddish brown in colour.

SERVICE, *Sorbus domestica*, occurs in Europe. A very hard, fine-grained, beautifully figured wood.

SWITCH, SORREL, *Dodonaea viscosa*, also known as Birch, occurs throughout the Tropics. A durable, very hard, close-grained wood, with heartwood dark brown and sapwood white.

TULIP WOOD, *Harpullia pendula*, occurs in Queensland. An easily worked though tough wood, very close-grained and strong.

Fencing and Posts. Timbers used for fencing must in the first place be of such a nature that they are not affected by contact with the soil, they must also withstand the weather. Strength is also an advantage, but not of so great a necessity as in some other cases. The majority of the timbers used for fencing are also put to more important uses, but we list them here for convenience' sake.

ANJAN (Sleepers).

APPLE, BROAD-LEAVED (Wheels).

ASH, RED (Furniture).

BEEF WOOD (Furniture).

BLOODWOOD (Sleepers).

CAJEPUT (Carriage building).

CANARY WOOD (Dyes).

CATALPA, *Catalpa speciosa*, occurs in Southern United States. A brown, somewhat weak but durable wood in contact with the soil. Soft and of coarse grain.

CEDAR, CANOE (Cooperage).

CEDAR, INCENSE (Furniture).

CEDAR, OREGON (Shipbuilding).

CEDAR, ROCK (Sleepers).

CEDAR, WHITE (Sleepers).

CEDAR, YELLOW (Sleepers).

CHESTNUT (Charcoal).

COFFEE TREE, *Gymnocladus canadensis*, occurs in Eastern United States. This, by the way, is not the tree from which coffee is obtained. A hard, strong, durable brown wood.

CYPRESS, PINE (Fig. 40) (Piles).

CYPRESS, SWAMP (Fig. 36) (Sleepers).

ELM, MOOSE (Shipbuilding).

FIR, SILVER (Pulp).

GUM, APPLE (Sleepers).

GUM, BROAD-LEAVED (Piles).

GUM, CABBAGE (Furniture).

GUM, MOUNTAIN (Fig. 1) (Sleepers).

GUM, NANKEEN (Sleepers).

GUM, SLATY (Sleepers).

GUM, SUGAR (Piles).

HACKBERRY (Wheels).

HEMLOCK SPRUCE (Sleepers).

HINAN (Sleepers).

IRONBARK, WHITE (Fig. 12) (Furniture).

LARCH (Wheels).

MYALL (Miscellaneous).

OAK, TURKEY (Charcoal).

PANACOCO (Cabinet making).

PINE, LONG-LEAF (Medicine).

RIMU (Cabinet making).

SPRUCE, SITKA (Charcoal).

STRINGY BARK (Fig. 4) (Wheels).

Flooring. Timber for this purpose should be moderately strong and capable of withstanding considerable wear. For the better class flooring a good appearance is also an essential.

ASH, BLUE (Coach building).

ASPEN (Pulp).

BALLY GUM, *Litsea reticulata*, also known as Cudgerie, occurs in Queensland. A close-grained, easily worked timber of a greyish colour.

BEECH, EVERGREEN (Musical Instruments).

CEDAR, OREGON (Shipbuilding).

GUM, SCRIBBLY (Coach building).

HORSE CHESTNUT, *Aesculus hippocastaneum* (Fig. 60), occurs in Europe and North America. A fine, close, even-grained, lustrous wood, not very durable but does not warp. White in colour, a sapwood tree.

PADOUK, *Pterocarpus indicus*, also known as Andaman, Redwood, Burmese Rosewood, Tenasserim Mahogany, occurs in Burma, the Andaman Islands and Southern China. A coarse, open-grained lustrous wood, takes a high polish. A substitute for Teak. Colour rich red, striped with black, but the colour fades on exposure to the air.

POPLAR, BLACK (Pulp).

STRINGY BARK (Fig. 4) (Wheels).

YELLOW WOOD, REAL, *Podocarpus Thunbergii*, also known as Upright Yellow wood,

Cape Geelhout, occurs in South Africa. A very fine, even-grained, satiny wood. Elastic, strong and easily worked, but liable to split. Yellow in colour.

Furniture. An enormous variety of timbers are used in the furniture trade. Wood for such a purpose should be strong, not liable to warp, ornamental and capable of taking a high finish.

AKASHIDE (Coach building).

ALDER (Fig. 24) (Charcoal).

ALDER, WHITE CAPE, *Platylophus trifolius*, occurs in Cape Colony. A hard, durable wood, tough and often beautifully grained. Takes a good polish, yellowish coloured.

ALMOND, WILD (Turnery).

ASH, AMERICAN, *Fraxinus americana*, also known as Green Ash, White Ash, Black Ash, Red Ash, Quebec Ash, United States Ash, Mountain Ash, White River Ash, occurs in North America. A coarse, open-grained, lustrous-surfaced wood. A tough, elastic, yet easily worked timber. Inferior to English Ash. Heart-wood reddish, sapwood white.

ASH, BLACK, *Fraxinus sambucifolia*, also known as Swamp Ash, Hoop Ash, Ground Ash, Nova Scotia Ash, occurs in North America, Canada and Nova Scotia. A coarse, open-

40 TIMBERS AND THEIR USES

grained, lustrous timber, soft, tough and elastic. Heartwood brown, sapwood much paler.

ASH, CAPE (Coach building).

ASH, OREGON (Cooperage).

ASH, RED, *Fraxinus pennsylvanica*, also known as Grey Ash and Brown-barked Ash, occurs in Southern Canada and Eastern United States. A coarse-grained, hard, strong, heavy timber. Heartwood rich brown, sapwood cream coloured.

ASSEGAI WOOD (Coach building).

BAKULA (Building).

BANKSIA, *Banksia littoralis*, also known as Seaside Banksia, occurs in Western Australia. A fine, open-grained wood with a silky surface, "slightly sticky to the touch." Heartwood reddish brown, sapwood whitish brown, beautifully grained.

BASSWOOD (Cooperage).

BEAD TREE, *Melia composita*, also known as White Cedar, Cape Lilac, Pride of India, Persian Lilac, occurs in India, Australia, China and Syria. A soft, easily worked wood taking a good polish. Liable to warp. Heartwood yellowish brown, sapwood yellowish white.

BEECH (Fig. 56) (Charcoal).

BEECH, AMERICAN, *Fagus ferruginea*, also known as Red Beech, occurs in Canada, United States, Nova Scotia, New Brunswick. Almost

identical with Common Beech. A hard, strong, coarse-grained timber, taking an excellent polish but liable to warp. Heartwood usually dark red, sapwood cream.

BEECH, EVERGREEN (Musical Instruments).

BEEFWOOD, *Grevillea striata*, also known as Silvery Honeysuckle, occurs in Australia. A hard, close-grained wood which takes a good polish. Red coloured and receives its popular name from a supposed resemblance to raw beef.

BIRCH (Charcoal).

BIRCH, YELLOW (Wheels).

BLACKWOOD (Figs. 7-10) (Musical Instruments).

BOIS CHAIRE, *Tecoma leucoxydon*, occurs in Northern South America and Trinidad. An even-grained, hard, heavy wood, takes a good polish. Green in colour. Used in chair making, hence its name.

BUNYA-BUNYA (Turnery).

CANNON BALL TREE (Wheels).

CEDAR, CANOE (Cooperage).

CEDAR, DEODAR (Sleepers).

CEDAR, INCENSE, *Libocedrus decurrens*, also known as White Cedar, Post Cedar, Bastard Cedar, occurs in Western United States. A fine, close-grained timber. Greyish brown in colour.

CEDAR, MOULMEIN, *Cedrela toona* (Fig. 20), also known as Toon, Indian Mahogany, Red Cedar, Cedar, Bastard Mahogany, Chittagong

wood, Bastard Cedar, occurs in Burma, India, Queensland, New South Wales, Java, Malacca and Brazil. A coarse, open-grained, lustrous wood. Easy to work, does not warp. "Equal to the best mahogany." Colour very deep red.

CEDAR, PENCIL (Fig. 18) (Engraving).

CEDAR, TASMANIAN, *Arthrotaxis selaginoides*, also known as King William Pine, occurs in Tasmania. A strong, even-grained, yellow wood.

CEDAR, WEST INDIAN (Miscellaneous).

CHAMPAK, *Michelia Champaca*, occurs in India, Ceylon and Malacca. A soft, easily polished wood, of a greenish colour.

CHAPLASH (Shipbuilding).

CHESTNUT, MORETON BAY, *Castanospermum australe* (Fig. 22), also known as Black Bean, Bean tree, occurs in Queensland and New South Wales, introduced into India and South Africa. A coarse, open-grained wood which takes a good polish. Heartwood very dark brown, often almost black, sapwood yellow.

CHITTAGONG WOOD, *Chukrasia tabularis*, also known as Deodar, Cedar, Bastard Cedar, occurs in India. A hard, lustrous wood, easily worked. Colour a rich brown.

CIROUABALLI, YELLOW, *Nectandra pisi*, also known as Yellow Siruaballi, occurs in British

Guiana. A fine, even-grained, almost lustrous wood. It works well and takes a good polish. Heartwood pale brown, sapwood cream.

CRAB WOOD, *Carapa guianensis*, also known as Carapa, Caraba, Carbaballi, Caribaballi, occurs in British Guiana and Trinidad. A coarse, open-grained wood. Easily worked and polished. Heartwood rich brown, sapwood yellowish.

CUCUMBER TREE (Turnery).

CYPRESS PINE (Fig. 40) (Piles).

DEL, *Artocarpus nobilis*, occurs in Ceylon. An open, even-grained, lustrous wood. Not easy to work on account of being cross grained. Difficult to polish. Olive brown in colour.

ELM WYCH (Shipbuilding).

GRANADILLO, *Amyris balsamifera*, also known as Funera, Rosewood, Mountain Torchwood, Legrium Rhodium, occurs in West Indies. A hard resinous wood of a red colour.

GRIGNON (Masts).

GUM, APPLE (Sleepers).

GUM, CABBAGE, *Eucalyptus sieberiana*, also known as Mountain Ash, Blackbutt, Gum top, Stringy Bark, Ironbark, White Ironbark, Bastard Ironbark, Green top, Silvertop, occurs in Australia and Tasmania. A coarse, cross-grained, easily worked, tough elastic wood. Pale brown colour.

44 TIMBERS AND THEIR USES

GUM, GIMLET (Engraving).

GUM, SWEET, *Liquidambar styraciflua*, also known as Hazel Pine, Satin Walnut, Red Gum, Californian Red Gum, Bilsted, Star-leaved Gum, Copalm, occurs in Mexico and United States. A very fine, close, even-grained wood. Tough but not strong. Difficult to season, warps badly, but takes a good polish. Only used for cheap furniture. Heartwood reddish brown, sapwood cream.

HACKBERRY (Wheels).

IRONWOOD, INDIAN, *Mesua ferrea*, also known as Indian Rose Chestnut, occurs in India. A very hard, strong timber. Difficult to work, but easily polished.

JACK (Musical Instruments).

JARRAH (Paving).

JHAND (Wheels).

KARRI (Wheels).

LACEBARK, *Hoheria populnea*, also known as Ribbon Wood, occurs in New Zealand. A coarse, open-grained timber, brown in colour.

LASRIN (Wheels).

LIGNUM VITAE (Fig. 62) (Cogs).

LIME (Fig. 15) (Charcoal).

MAHOGANY, SWAMP (Piles).

MANGO (Wheels).

MAPLE (Fig. 57) (Charcoal).

MAPLE, OREGON, *Acer macrophyllum*, also known as Broad-leaved Maple, Big-leaved Maple, Californian Maple, Fiddle-backed Maple, occurs in United States and Canada. A fine, dense, open-grained, lustrous wood. Often with a beautiful bird's-eye figure. Reddish brown heartwood, whitish sapwood.

MAPLE, RED (Turnery).

MAPLE, ROCK (Shipbuilding).

MAPLE, SILVER, *Acer saccharinum*, also known as Sugar Maple, Rock Maple, Sugar Tree, Bird's-eye Maple, Soft Maple, occurs in North America generally. A fine, dense, even-grained wood. Tough, strong, takes a good polish ; works well. Heartwood red-brown, sapwood cream.

MARBLEWOOD, ANDAMAN, *Diospyros Kurzii*, occurs in the Andaman Islands. A hard, close-grained, durable wood. Heartwood in bands of black and grey, sapwood yellowish.

MARGOSA, *Azadirachta indica*, also known as Margose, Nym, Nim, Hoop Tree, occurs in India, Burma, Malay Archipelago and Ceylon. A hard, heavy wood, not unlike Mahogany. Heartwood light red, sapwood yellowish.

MERANTI (Medicine).

MESQUITE, *Prosopis juliflora*, occurs in Mexico and Eastern United States. A soft, durable wood of a red colour.

MIRABOW (Sleepers).

MONKEY POT, *Lecythis grandiflora*, occurs in Guiana, Brazil and Tropical Africa. A dense, even-grained, lustrous wood. Very easily polished, but difficult to work. Heartwood orange, sapwood paler.

MOPANE, *Copaifera Mopane*, also known as Ironwood, occurs in West Africa. A heavy, durable wood, difficult to work.

MORA, *Dimorphandra excelsa*, also known as Moraballi, Moreira, occurs in Tropical America. A coarse-grained, lustrous wood. Very durable and easily polished. "It turns badly, planes well and smoothly, but is hard to saw." Heartwood dark reddish brown streaked with white, sapwood yellowish.

MYALL (Miscellaneous).

NETTLE TREE (Miscellaneous).

NOGAL, *Juglans australis*, occurs in Argentine. A straight-grained, easily worked, brown wood.

OAK, AFRICAN (Turnery).

OAK, CHINQUAPIN, *Quercus Muhlenbergii*, also known as Yellow Oak, Chestnut Oak, occurs in Eastern United States. A very strong, heavy, durable wood. Heartwood warm brown, sapwood pale brown.

OAK, FOREST, *Casuarina torulosa*, also known as She Oak, Beefwood, Mountain Oak, Ged-

raaid Beefwood, Australian Mahogany, Botany Bay Oak, Koondeba, River Oak, Noo Loi, occurs in Queensland, South Australia and New South Wales. A dense, even-grained, light-surfaced wood. Beautifully marked. Heartwood a network of brick red and light red, sapwood pale brown.

OAK, RED, *Quercus rubra*, also known as American Red Oak, Black Oak, Canadian Red Oak, occurs in North America, introduced into Europe. A heavy, coarse-grained wood. Heartwood red-brown, sapwood nearly white.

OAK, SHE, *Casuarina Fraseriana*, occurs in Western Australia. A fine open-grained, beautifully figured timber, works and polishes well. Heartwood pale red, sapwood light brown.

OAK, SHINGLE (Turnery).

OAK, SILKY, *Stenocarpus salignus*, also known as Beefwood, Silvery Oak, occurs in South Queensland, Eastern Australia, New South Wales. A coarse, open-grained, lustrous wood, marked with a well-defined figure. Heartwood deep red, sapwood brown.

OAK, TURKEY (Charcoal).

OLIVE, WILD, *Olea verrucosa*, occurs in Southern Europe. A fine-grained, smooth, dull-surfaced wood. Prettily figured, turns and polishes well. Colour " yellowish brown with varied bands of

48 TIMBERS AND THEIR USES

white passing through brown to black. Heartwood not sharply defined from the yellowish sapwood."

PACARA, *Enterolobium timbuova*, occurs in North Argentina. An open-grained, pale brown wood.

PADER, *Stereospermum chelonoides*, also known as Padri, occurs in India, Burma and Ceylon. A hard, elastic wood, easily worked, varying in colour from grey to rich brown.

PADOUK (Flooring).

PLANE, EASTERN (Cabinet making).

PURPLEHEART, *Copaifera pubiflora*, occurs in Tropical America. A close-grained, hard, elastic wood. Easily worked and polished. Dark brown, almost purple in colour.

QUAR, *Euclea undulata*, occurs in South Africa. A hard, close-grained wood. Nicely figured. Heartwood dark brown, sapwood pale brown.

REDWOOD (Cabinet making).

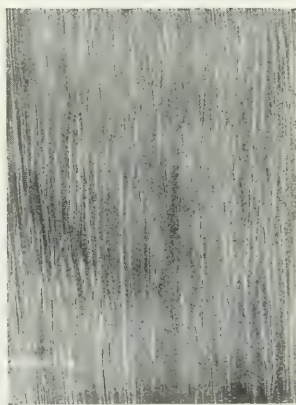
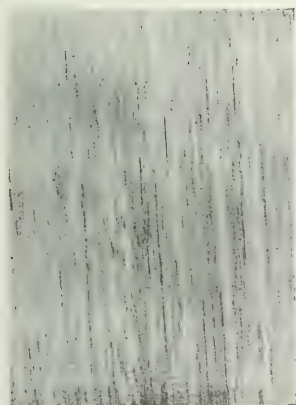
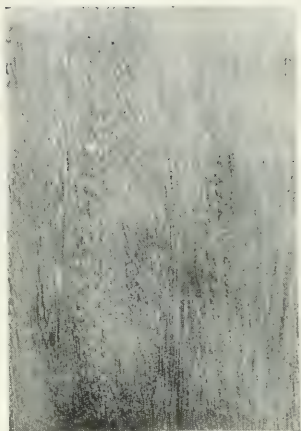
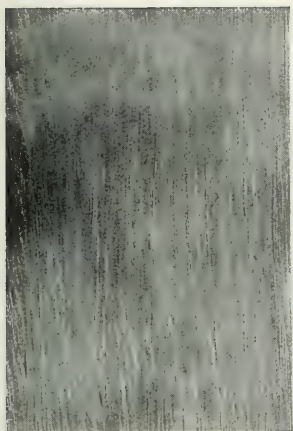
RIMU (Cabinet making).

ROSEWOOD, BRAZIL (Musical Instruments).

SABICU (Shipbuilding).

SAFFRON WOOD, *Elaeodendron croceum*, also known as Saffron-hout, Crocus Tree, Saffron, Safforan, occurs in South Africa. A very fine, close-grained, bright-surfaced wood. Heartwood reddish, sapwood yellowish.

SANDAN, *Ougeinia dalbergioides*, occurs in

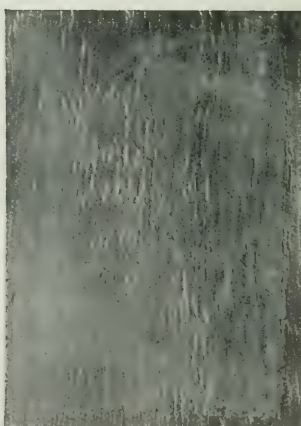
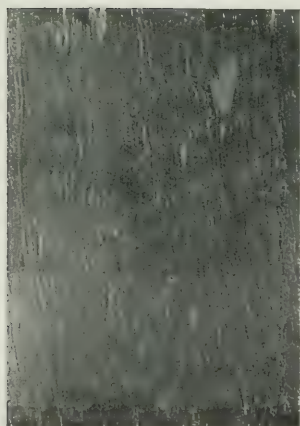
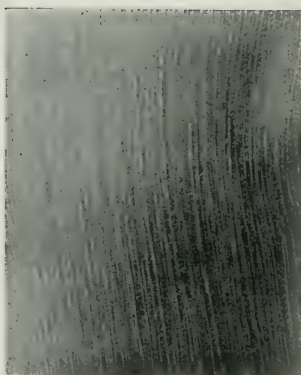
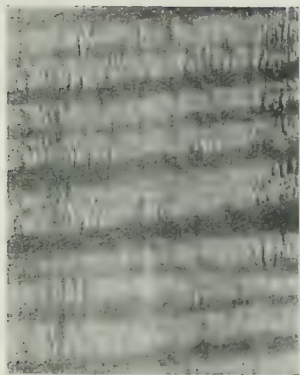


1. BLUE GUM.

3. SPOTTED GUM.

2. GREY GUM.

4. STRINGY BARK.



5. AUSTRALIAN BOX.

6. BLACKBUTT.

7. BLACKWOOD (FIGURE).

8. BLACKWOOD (FIGURE).

Northern India. A close-grained, hard wood, easily polished and very durable.

SAPODILLA, *Achras sapota*, also known as Bully, Bullet Wood, Nispero, occurs in Tropical America. A hard, heavy, red-brown wood.

SASSAFRAS, CAYENNE (Shipbuilding).

SATINWOOD, WEST INDIAN, *Fagara flava*, also known as Yellow Wood, occurs in West Indies. A very close, even-grained wood, often well figured. Colour variable, yellow and brown.

SILKBARK (Turnery).

SIRIS, PINK, *Albizzia fulibrissin*, also known as Sirissa, Sirsa, occurs in Tropical Asia and Africa. A hard, close-grained wood, easily polished, almost black in colour.

SISSOO (Wheels).

SNEEZEWOOD (Bridge building).

STINKWOOD (Building).

STRINGY BARK (Fig. 4) (Wheels).

TAMARAK, WESTERN (Sleepers).

TEAK, BASTARD (Building).

THITKA, *Pentace burmanica*, also known as Kathitka, occurs in Burma, Java, Molacca. An even-grained, soft wood of a yellowish colour. Easily polished.

TONKA BEAN (Medicine).

UMBRELLA TREE, *Thespesia populnea*, also known as Portia Tree, Tulip Tree, Native Rosewood, Poppy Tree, occurs in India, Burma,

Ceylon, the Andaman Islands, Tropical Africa. A fine, open-grained, bright-surfaced wood. Heartwood rich dark brown, sapwood cream.

WALNUT, EAST INDIAN (Building).

WANDOO (Sleepers).

ZEBRA WOOD, *Connarus guianensis*, occurs in British Guiana. An excellent furniture wood, for it is beautifully figured, easily worked and polished.

ZELKOVA, *Zelkova crenata*, occurs in Eastern Europe. A heavy, hard, easily polished wood. Heartwood reddish, sapwood pale cream.

Handles. Timber used in the manufacture of handles for tools, agricultural instruments and the like should be capable of being turned, yet hard and tough, and not liable to split or warp. The majority of the handle woods are also used for other purposes, but we list them here for ease of reference.

APPLE, OREGON CRAB, *Pyrus rivularis*, occurs in North America. A close-grained, heavy, hard wood of a red-brown colour.

ASH, BLUE (Carriage building).

ASH, BLUEBERRY (Cabinet making).

ASH, BRUSH, *Acronychia Baueri*, occurs in New South Wales and Queensland. A close-grained, hard, strong wood.

ASSEGAI WOOD (Carriage building).

BALBUL (Wheels).
BEECH, AMERICAN (Furniture).
BOX, BASTARD (Shipbuilding).
CANARYWOOD (Dyes).
CANNON BALL TREE (Wheels).
COACH WOOD (Carriage building).
ELM, AMERICAN (Fig. 51) (Cooperage).
GUM, RED (Piles).
HICKORY, SHELL-BARK (Wheels).
MAPLE, OREGON (Furniture).

Inlaying and Lacquer Work. The chief desideratum in a timber for inlaying is that it should be ornamental.

CHERRY (Miscellaneous).

COCOBOLA WOOD. A timber of unknown species from British Guiana. "The showiest and most strikingly coloured of all our commercial woods." A coarse-grained, bright-surfaced wood with a heartwood "deep orange or orange-red streaked with sharply marked jet-black lines." Sapwood pale brown.

EAGLE WOOD, *Aquillaria Agallocha*, also known as Black Agallocha, Agila Wood, Lign-Aloes, Aloes Wood, occurs in India. "Large trees with whitish or light yellow wood, containing an abundance of resin and an essential oil, much valued as a perfume and possibly the 'Aloes' of Psalm XLV. The wood retains its fragrance

for years, and is burnt in Indian temples and also used for inlaying and as a setting for jewels."

EBONY, AMERICAN (Musical Instruments).

HINOKI, *Cupressus obtusa*, also known as Japanese Cypress, occurs in Japan. A fine-grained, easily polished wood. With a rose-red heart and pale yellow sapwood. "One of the best of Japanese timbers, held sacred by the followers of the Shinto faith, whose temples are built of it, as also are the palaces of the Mikado."

HOLLY (Engraving).

JUNIPER, AUSTRALIAN, *Myoporum serratum*, also known as Cockatoo Bush, Blueberry, Native Currant, Native Myrtle, occurs in Australia. A small tree with a hard, white timber.

KEYAKI, *Zelkova acuminata*, also known as Japanese Elm, occurs in Japan. Used only for common lacquer.

KIZI, *Paulownia imperialis*, also known as Paulownia, occurs in Japan, introduced into this country. An exceedingly light wood, very compact, not liable to warp or split. Yellowish white in colour.

MULBERRY, *Morus alba*, occurs in Europe and Eastern Asia. A hard lustrous wood difficult to split. Heartwood brownish yellow, sapwood pale yellow.

REWA-REWA, *Knightia excelsa*, also known as the Honeysuckle, New Zealand Honeysuckle, White Honeysuckle, Coast Honeysuckle, Honeysuckle Wood, occurs in New Zealand. A very fine, close-grained wood. Easy to work, takes a good polish. Of a reddish colour figured with dark lines.

SUGI, *Cryptomeria japonica*, also known as Japanese Cedar, occurs in China and Japan, introduced into this country. A red-brown wood, used only for cheap lacquer ware.

TULIP WOOD, *Physocallyma scaberrimum*, also known as Bahia Tulip Wood, occurs in Brazil and Peru. An open-grained, dense, lustrous wood. "Flesh and blood colour, somewhat resembling that of striped red and white tulips."

Masts. Wood for use as masts must be strong and straight, capable of withstanding great strain and not injuriously affected by the weather.

ARJUN, *Terminalia Arjuna*, occurs in India, Burma and Ceylon. A very heavy, strong, durable, red-brown wood.

CRABWOOD (Furniture).

GRIGNON, *Bucida angustifolia*, occurs in Guiana. A strong, even, straight-grained, straight-growing, light red timber.

GRIGNON FOU, *Qualea caerulea*, occurs in Guiana. A straight-grained, straight-growing timber, but not so strong as Grignon.

HALDU, *Adina cordifolia* (Fig. 33), occurs in India, Burma and Ceylon. A close-grained, easily worked timber of a pale yellow colour.

KAURI (Fig. 42) (Sleepers).

PINE, OREGON, *Pseudotsuga Douglasii* (Figs. 47-48), also known as Douglas Pine, Douglas Fir, Douglas Spruce, Yellow Pine, Yellow Fir, Red Fir, Red Pine, occurs in North America. A close-grained, even, smooth timber; strong and straight. Durable and difficult to work. Colour bands of dark and light brown.

TANEKAHA (Sleepers).

Medicine, etc. Under this heading are included a variety of woods from which medicines and other chemical products are obtained. Their utility, like the woods from which dyes are obtained, depends upon their active principles and the ease with which they can be extracted.

BUCKTHORN, CANADIAN, *Rhamnus purshiana*, also known as Bearberry, Barberry, Wild Cherry, Bearwood, Sacred Bark Buckthorn, Shittim Wood, Cascara Sagrada, occurs in North America. A dense, compact, lustrous wood. Colour, "light yellowish brown streaked with purplish

brown, and with light yellow sapwood. Cascara sagrada is obtained from the bark.

CAMPHOR, *Cinnamomum camphora*, occurs in China, Japan and Formosa. A soft, pale-coloured timber, from which camphor is obtained by distillation.

CHIR (Charcoal). From this tree turpentine is derived.

FIR, BALSAM, *Abies balsama*, also known as Balm of Gilead Fir, American Silver Fir, occurs in Eastern North America. A soft, coarse-grained, light timber, yellowish in colour. From this wood Canada balsam is obtained.

MERANTI, *Hopea Maranti*, occurs in Malay Peninsula. A heavy, soft red wood from which Dammar resin is obtained.

PINE, CLUSTER, *Pinus pinaster*, also known as Sea Pine, Maritime Pine, occurs in Mediterranean region, but introduced into Africa, India and Australia. A very smooth, even-grained wood; white in colour, banded with darker wood. A source of turpentine and lampblack, also largely used for pit props.

PINE, LONG-LEAF, *Pinus palustris*, also known as Pitch Pine, Long-leaved Yellow Pine, Yellow Pine, Broom Pine, Southern Pine, Hard Pine, Georgia Pine, Red Pine, Brown Pine, Swamp Pine, Turpentine Tree, Pensacola Pine, Long Straw Pine, occurs in Southern United States,

introduced into this country. The most important source of turpentine in the world. Sargent says, "Invaded from every direction by the axe, a prey to fires, which weaken the mature trees and destroy the tender saplings, wasted by the pasturage of domestic animals, and destroyed for the doubtful profits of the turpentine industry, the forests appear hopelessly doomed to lose their commercial importance at no distant date." A fine, smooth, compact wood. Durable and strong. Heartwood alternately banded with reddish and brownish bands, sapwood pale yellow.

PINEY, VARNISH, *Vateria indica*, also known as White Dammar and Indian Copal, occurs in Ceylon and South India. A tough, hard wood with a grey heart and a pinkish sapwood. Copal is obtained from this tree.

QUASSIA, *Picranea excelsa*, also known as Bitter wood, Bitter Ash, occurs in Brazil, Guiana and the West Indies. A fine, open-grained, lustrous wood. Yellowish white, a sapwood tree. Used in medicine as a tonic, also in horticulture as an insecticide.

QUININE, *Cincona calisaya*, also known as Jesuit's Bark, Calisaya Tree, Peruvian Bark, Cinchona, Cinchona Bark, occurs in the Andes. A small tree from the bark of which quinine is obtained.

ROSEWOOD, CANARY, *Convolvulus scoparius*, occurs in the Canary Islands. Useless as a timber, but the source of an oil used to adulterate attar of roses.

RUBBER, *Hevea guyanensis*, occurs in Brazil. There are many trees from which rubber is obtained, but the most important is the Brazilian rubber tree. The rubber of commerce is the latex of the tree.

SANDALWOOD, *Santalum album*, occurs in India and Malay Archipelago. A very fine, even, bright-surfaced wood. Heartwood yellow-brown, sapwood white. From the wood a valuable oil, used in medicine and perfumery, is obtained.

TEREBINTH, *Pistachia terebinthus*, occurs in Mediterranean region. Yield's medicinal turpentine.

TONQUIN BEAN, *Coumarouna odorata*, also known as Tonka Bean, Cuamara, occurs in Northern South America. A hard, cross-grained, durable wood. Difficult to work, but readily polished. Strong. Rich brown in colour. Used in medicine.

Musical Instruments. All timbers used in the manufacture of musical instruments must, of necessity, be resonant and free from knots. Handsome appearance and a capacity for taking

a good finish is, of course, an added attraction.

BEECH, EVERGREEN, *Fagus Cunninghamii*, also known as Negro-head Beech, Myrtle, occurs in Victoria and Tasmania. A satin-surfaced, well-figured wood, capable of taking a high polish. Hard and knot-free. Red-brown in colour. Used in the manufacture of pianos.

BLACKWOOD, AUSTRALIAN, *Acacia melanoxylon* (Figs. 7-10), also known as Black Wattle, Lightwood, Hickory, Black Sally, Silver Wattle. Occurs in South Australia, introduced into North America, India and South Africa. A fine, straight, even-grained wood. Easily worked and polished. Somewhat liable to warp. "One of the most valuable timbers of Australia." Heartwood rich red, sapwood nearly white. Used for sounding boards of pianos.

BOIS CHAIRE (Furniture). Used for the sounding boards of pianos.

BRAZIL WOOD, *Caesalpinia brasiliensis*, occurs in Tropical America. A hard, heavy, easily polished wood, used for making violin bows. Rare.

EBONY, AMERICAN, *Brya ebenus* (Fig. 30), also known as Green Ebony, West Indian Ebony, Jamaica Ebony, Brown Ebony, Billy Web, Cocus, Cocos Wood, Granadillo, Granillo, Chichipate,

occurs in Tropical America and West Indies. A very fine-grained, dense, even timber. Easily worked and turned. Heartwood brown, almost black, sapwood canary yellow. Used in the manufacture of flageolets and flutes.

ELS, *Rhus Thunbergii*, also known as Rock Ash. Klip, occurs in South Africa. A close-grained, hard, tough wood.

JACK, *Artocarpus integrifolia*, also known as Jak Wood, Jaack Wood, Jaca Tree, Orange Wood, Kos, occurs in India and Ceylon, Brazil, West Indies, Malay Archipelago. A coarse-grained, moderately hard wood, liable to warp ; yellowish brown in colour.

LOQUAT, *Eriobotrya japonica*, also known as Biwa, occurs in Japan. A heavy, hard, straight-grained wood.

MAPLE, NORWAY, *Acer platanoides*, also known as Plane Maple, occurs in North Eastern and Central Europe. A hard, tough, easily worked and polished wood, pale grey in colour.

PALISANDER WOOD, *Jacaranda brasiliiana*, occurs in Brazil. A hard, heavy, close-grained wood. Heartwood rich brown with black bands, sapwood grey. Used in making pianos.

PEAR, HARD, *Olinia cymosa*, var. *intermedia*, occurs in Cape Colony. A hard, close-grained, heavy, tough wood, yellowish in colour.

PLUM, *Prunus domestica* (Fig. 59), occurs in

Western Asia, but introduced almost everywhere in the temperate regions of the world. A heavy, hard wood, none too durable. Heartwood red-brown, sapwood yellowish.

ROSEWOOD, BRAZILIAN, *Dalbergia nigra*, also known as Jacaranda Wood, Jacaranda Cabiuna, Caviuna, Jacaranda Preto. A coarse, even-grained, dense wood. Very dark brown, almost black in colour, striped with still darker brown. Used in making cases of pianos.

SPRUCE (Charcoal). Used for making sounding boards.

SPRUCE, BLACK (Pulp). Used for sounding boards of pianos and violins.

WALNUT, *Juglans regia* (Fig. 55), also known as English, Auvergne, Italian, Circassian and European Walnut, occurs in Europe and parts of Asia. An open-grained, lustrous wood. Tough. Mainly used for the making of gun stocks for which purpose it is unequalled. Heartwood brown, sapwood grey. Used in piano making.

Paving. Timbers for this purpose must be exceptionally strong and resistant of wear, they must also be unaffected by alternate dryness and moisture.

ACLE (Piles).

BLACKBUTT (Fig. 6) (Wheels).

GUM, SPOTTED, *Tristania maculata* (Fig. 2), occurs in Eastern Australia. A coarse-grained, tough, strong and durable wood. Brown in colour.

IRONBARK, RED, *Eucalyptus siderophloia*, also known as Broad-leaved Ironbark, occurs in New South Wales and Queensland. A hard, heavy, tough wood. Dark red in colour. Little cut now owing to the scarcity of matured trees.

JARRAH, *Eucalyptus marginata*, also known as Mahogany Gum, Australian Mahogany, Yarrow Tree, Curly Jarrah, Bastard Mahogany, occurs in Victoria, Western Australia and New Zealand. A coarse, sinuous-grained wood, with a dull surface. Very durable. "It appears imperishable, excellent qualities for paving." Works easily and takes a good polish.* Almost unflammable. The most valuable of Australian timbers. Heartwood "the colour of dried blood with black zones here and there," sapwood pale brown.

KARRI (Wheels).

MAHOGANY, RED (Piles).

OSAGE, ORANGE, *Maclura aurantiaca*, also known as Boxwood, occurs in Southern United States. A coarse-grained, heavy, durable wood. Heartwood varies in colour with the direction of the cut, transversely it is brown, longitudinally yellow, sapwood yellow.

‘ PINE, LONG LEAF (Medicine).

SAJ, *Terminalia tomentosa*, occurs in India and Burma. A heavy, hard, durable wood. Difficult to work, but easily polished. Heartwood dark brown, sapwood white.

TALLOW WOOD, *Eucalyptus microcorys* (Fig. 67), also known as Forest Mahogany, Peppermint, Turpentine Tree, Tee, occurs in Queensland and Eastern Australia. A close-grained, hard, durable wood. “One of the best woods for paving.” Yellowish in colour and greasy, hence its name.

Piles. Woods used for making piles should be strong, but one quality which is essential above all others is durability when submerged and in contact with damp soil. Those timbers capable of resisting Shipworm (Teredo) are especially valuable.

ACLE, *Xylia dolabriformis*, occurs in India, Malay Peninsula and the Philippines. A strong, tough, rigid wood; difficult to work, but taking a good polish. “More indestructible than iron.” Not attacked by shipworm. Heartwood red-brown.

ALDER (Fig. 24) (Charcoal).

BIRCH, BLACK. *Fagus solandri*, also known as New Zealand Birch, Entire-leaved Beech, White Birch, Towhai, Towai, occurs in New

Zealand and is really a Beech. A very hard, durable wood, but is only useful for fresh-water piles as it is liable to the attacks of shipworm. Brown in colour.

BLOODWOOD (Sleepers).

BOX, JAMAICA, *Tecoma pentaphylla*, also known as West Indian Box, Zapatero, White Cedar, Cogwood, White Wood, occurs in West Indies, Brazil and Central America. A fine, close-grained, dull-surfaced wood, remarkably free from knots. Yellow coloured; a sapwood tree.

CANARY WOOD (Sleepers).

CEDAR, DEODAR (Sleepers).

CYPRESS PINE, *Callitris robusta* (Fig. 40), also known as White Pine, Murrumbidgee Pine, Black Pine, Dark Pine, Common Pine, Lachlan Pine, Murray Pine, Camphor Wood, occurs in Northern and Eastern Australia. A straight-grained, easily worked and easily polished, durable wood. Shipworm proof. The most durable soft wood in the world. Varies in colour from dark to light brown.

ELM, CANADIAN (Fig. 52) (Carriage building).

GREENHEART, *Nectandra rodioei*, also known as Yellow Greenheart, Sipiri, Sipiera, Bibiru, Geelheart, occurs in Tropical South America. A coarse-grained, smooth, lustrous timber. Heartwood proof against shipworm. Very tough,

strong and elastic. Colour green, greenish brown and sometimes almost black.

GUM, RED, *Eucalyptus rostrata*, also known as Yellow Jacket, Murray Red Gum, Blue Gum, White Gum, Creek Gum, Forest Gum, Flooded Gum, River Gum, occurs in Eastern Australia. A very hard wood, difficult to work, but easily polished. Shipworm proof. Deep red colour.

GUM, SALMON (Wheels).

GUM, SUGAR, *Eucalyptus corynocalyx*, occurs in South Australia. A very strong, heavy wood. Durable. Shipworm proof. Pale yellow in colour.

GUM, BROAD-LEAVED WATER, *Tristania suaveolens*, also known as Mahogany, Swamp Mahogany, Bastard Peppermint, occurs in Eastern Australia. A close-grained, hard, elastic wood. Very durable and shipworm proof. "The most esteemed of all woods for use as piles in sea water."

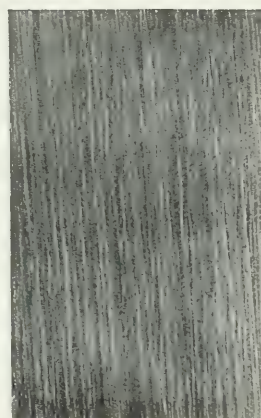
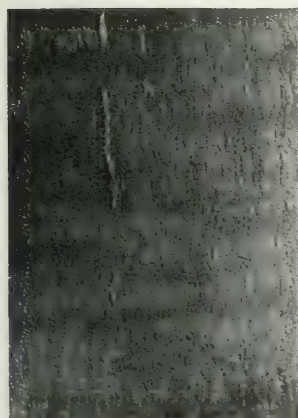
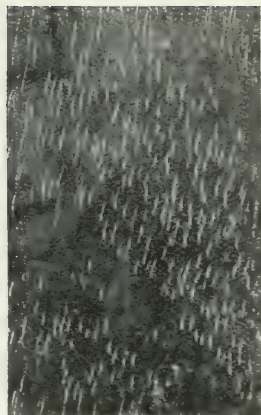
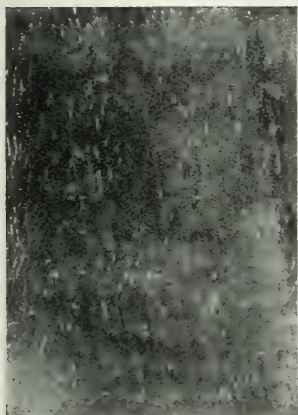
IRONWOOD, BORNEO, *Eusideroxylon Zwageri*, also known as Billian, occurs in British North Borneo. Strong, durable and shipworm proof. "Resembling Oak when newly cut, but with age or exposure become black as ebony."

JARRAH (Paving).

KARRI (Wheels).

LARCH (Wheels).

LOCUST, BLACK (Fig. 23) (Wheels).

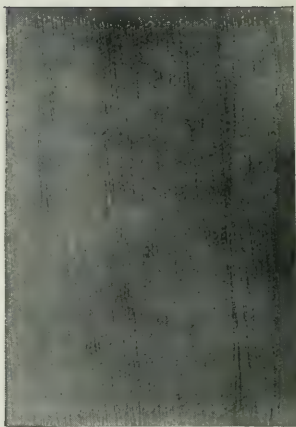
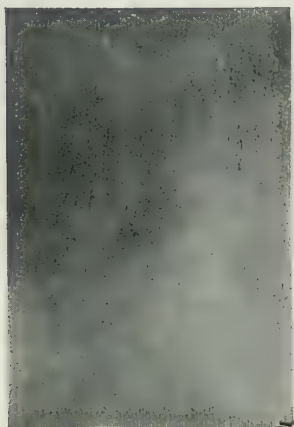


9. BLACKWOOD (FIDDLE).

11. MESSMATE.

10. BLACKWOOD (PLAIN).

12. IRONBARK.



13. POPLAR.

15. LIME.

14. COTTONWOOD.

16. TULIP TREE.

MAHOGANY, RED, *Eucalyptus resinifera* (Fig. 2), also known as Australian Red Mahogany, Red Gum, Red Stringybark, Jimmy Low, Forest Mahogany, Grey Gum, Botany Bay Gum, Hickory, occurs in North Eastern Australia. A coarse, cross-grained wood. Very strong and durable, resists shipworm. Colour dark red, sapwood brown.

OAK, *Quercus robur* (Figs. 70-72), occurs in Europe. A very coarse, open-grained wood. The heartwood, when properly seasoned, forms one of the most durable of all timbers. "The piles of Old London Bridge, taken up in 1827, after six and a half centuries' use, are a striking instance of these lasting qualities." The heartwood is brown and the sapwood paler brown.

OAK, ZEEN (Cooperage).

PINE, BLACK, *Prumnopitys spicata*, occurs in New Zealand. A close, even-grained wood. Easily worked and durable. Yellow-brown colour.

PINE, WESTLAND (Sleepers).

PURIRI (Sleepers).

SILVER TREE, *Tarrietia argyrodendron*, also known as Ironwood, Stonewood, Crow's Foot Elm, Black Stavewood, occurs in North Eastern Australia. A close-grained, tough, hard, white wood.

STRINGY BARK (Fig. 4) (Wheels).

TALLOW WOOD (Fig. 69) (Paving).

TANEKAHA (Sleepers).

TOOART (Shipbuilding).

TOTARA, *Podocarpus Totara*, also known as New Zealand Yew, occurs in New Zealand. A very fine, even, close-grained wood. Resists shipworm. Very durable. "Not affected by wet, which rather preserves than injures it." Easily worked. Never warps. One of the most valuable of New Zealand woods. Heartwood rich red, sapwood white.

TURPENTINE TREE, *Syncarpia laurifolia* (Fig. 34), occurs in North Eastern Australia. A light, easily worked wood. Durable in the ground or in water. Almost unflammable. Shipworm proof.

Pulp. Woods used in the manufacture of paper pulp are all such as have a high cellulose content.

ASPEN, *Populus tremula*, occurs in Europe. A light, elastic wood of a cream colour. A sapwood tree.

ASPEN, AMERICAN, *Populus tremuloides*, also known as Quaking Asp, occurs in North America. A close-grained, soft wood. Not durable. Heartwood brown, sapwood white.

BASSWOOD (Cooperage).

BIRCH, CANOE, *Betula papyrifera*, also known

as Paper Birch, White Birch, occurs in Canada and the Northern United States. A hard, heavy, strong, but not durable wood. Heartwood rich brown, sapwood white.

BIRCH, OLDFIELD, *Betula populifera*, also known as Poplar-leaved Birch, Grey Birch, White Birch, occurs in Canada. A fine-grained, light, non-durable wood. Heartwood pale brown, sapwood dirty white.

BUCKEYE, OHIO, *Aesculus glabra*, occurs in Eastern United States. An even-grained, easily worked, light wood. Cream coloured.

FIR, SILVER, *Abies pectinata*, also known as Swiss Pine, occurs in Central and Southern Europe. A strong, elastic, easily worked timber of a yellowish colour.

MAPLE, ASH-LEAVED, *Negundo aceroides*, also known as Negundo, Black Ash, Box Elder, occurs in Southern United States. A light, non-durable wood ; white.

POPLAR, BALSAM, *Populus balsamifera*, also known as Tacamahac, Balsam, Balm of Gilead, occurs in North America. A light, non-durable wood. Heartwood pale brown, sapwood white.

POPLAR, BLACK ITALIAN, *Populus monilifera*, also known as Lacewood, Cottonwood, Big Cottonwood, Poplar. Necklace Poplar, Carolina Poplar, Swiss Poplar, Whitewood, occurs in North America. A fine, open-grained, lustrous

wood. Easy to work, durable. The quickest growing of all Poplars. Heartwood brown, sapwood white.

POPLAR, LARGE-TOOTHED, *Populus grandidentata*, also known as Whitewood, Large Aspen, occurs in North America. A soft, white, easily worked wood.

SPRUCE, *Picea excelsa*, also known as Spruce Fir, White Deal, White Fir, Norway Spruce, Swiss Pine, Violin Wood, occurs in mountainous parts of Europe. A straight-grained, straight-growing, light elastic wood. Easily worked. Durable. Colour of heartwood and sapwood white and brown.

SPRUCE, BLACK, *Picea nigra*, also known as American Spruce, Canadian Spruce, Double Spruce, New Brunswick Spruce, St. John's Spruce, Muskeg Spruce, occurs in Northern parts of North America. A light, elastic, though soft wood, strong. Heartwood reddish white, sapwood white.

SPRUCE, RED, *Picea rubra*, occurs in Eastern Canada and United States. A strong, elastic timber, very similar to Black Spruce.

Shipbuilding. Timber used for ship and boat building must possess a number of qualities not required in wood used for any other purpose. It must be strong and durable in contact with

water, not liable to deteriorate in contact with metal or to be attacked by shipworm. Except for small boats, the question of weight is not important.

ACLE (Piles).

AKAGASHI (Carriage building).

ALDER, WHITE (Furniture).

ANAN (Bridge building).

ANGELIN (Building).

ANGELIQUE, *Dicorynia paraensis*, occurs in Northern South America. A straight-grained, strong, elastic wood. Durable, not attacked by shipworm. Easily worked. Red-brown. "Used in French dockyards, as a substitute for Teak, for backing armour plates, etc. ; far more durable than Oak."

ANGELLY (Building).

BALBUL (Wheels).

BEECH (Fig. 56) (Charcoal).

BIRCH, GREY (Pulp).

BOTTLEBRUSH, RED (Wheels).

BOX, JAMAICA (Piles).

BOX, SCRUB, *Tristania conferta*, also known as Bastard Box, Brisbane Box, Brush Box, Red Box, White Box, Brisbane Mahogany. A strong, tough, elastic wood, liable to warp. Brown colour.

BUTTERNUT (Carriage building).

CAJEPUT (Carriage building).

CASHEW (Charcoal).

CEDAR, CANOE (Cooperage).

CEDAR, GUIANA (Building).

CEDAR, MOULMEIN (Furniture).

CEDAR, OREGON, *Cupressus Lawsoniana* (Fig. 37), also known as Port Orford Cedar, Lawson's Cypress, Ginger Pine, occurs in Western United States. A close-grained, strong, durable, easily worked wood. Smells of ginger when freshly cut. Very pale brown.

CEDAR, PENCIL (Fig. 18) (Engraving).

CEDAR, TASMANIAN (Furniture).

CEDAR, WHITE (Sleepers).

CEDAR, YELLOW (Sleepers).

CHAMPAK (Furniture).

CHAPLASH, *Artocarpus Chaplasha*, also known as Thorny Jack, Lesser Jack, occurs in India. An even-grained, durable, yellow-brown wood.

COACH WOOD (Carriage building).

ELM, MOOSE, *Ulmus fulva*, also known as Slippery Elm, Red Elm, occurs in North Eastern United States and Southern Canada. A hard, strong, durable, elastic wood. Used for ribs of boats. Red-brown in colour.

ELM, WYCH, *Ulmus montana*, also known as Scotch Elm, Mountain Elm, Chair Elm, Wych Hazel, occurs in Britain. A straight-grained, somewhat soft, pale brown wood.

FIR, SILVER (Pulp).

GUARABU, *Terminalia acuminata*, occurs in Brazil. A straight-grained, dense, purple-brown wood.

GUM, BLUE (Fig. 1) (Carriage building).

GUM, SPOTTED (Fig. 2) (Paving).

HIBA (Bridge building).

IRONWOOD, CAPE, *Sideroxylon inerme*, also known as White Ironwood of Mauritius, Soft Milkwood, White Milkwood, occurs in East and South Africa, Mauritius. A close-grained, very heavy, durable wood. Yellowish, marked with brown.

JACK (Musical Instruments).

JACK, LONG, *Flindersia Oxleyana*, also known as Light Yellow Wood. A good quality wood. Strong, durable, moderately hard. Yellowish.

JARUL, *Lagerstraemia flos-reginae*, also known as Queen Lagerstraemia, occurs in India, Ceylon and Burma. A close-grained, hard, lustrous wood. "The most valuable timber of North-east India and second only to Teak in Burma." Pale red-brown in colour.

KARRI (Wheels).

LEATHER JACKET (Wheels).

MAHOGANY, BASTARD (Paving).

MAHOGANY, EAST INDIAN, *Soyimida febrifuga*, also known as Bastard Cedar, Indian Redwood,

72 TIMBERS AND THEIR USES

Coromandel Redwood. A fine-grained, hard, easily worked, durable wood. Dark red.

MAHOGANY, SWAMP, *Eucalyptus robusta*, also known as White Mahogany, Brown Gum, occurs in New South Wales. A cross-grained, durable wood. Not easy to work. Brown to red in colour.

MAHWA (Wheels).

MANGOSTEEN (Carriage building).

MAPLE, ROCK, *Acer barbatum*, also known as Hard Maple, Sugar Maple, Sugar Tree, Bird's-eye Maple, occurs in Canada and North Eastern United States. A fine-grained, smooth, dense wood. Tough, strong and, when properly seasoned, durable. Takes a good polish. Heartwood yellowish white and very pale brown, sapwood cream coloured.

MORA (Furniture).

MULBERRY, RED, *Morus rubra*, occurs in Eastern United States. A coarse-grained, tough, strong, durable wood. Heartwood orange, sapwood nearly white.

MYRTLE, RED, *Eugenia myrtifolia*, also known as Brush Cherry, Native Myrtle, occurs in North Eastern Australia. A strong, elastic, yellowish wood. Easily worked.

OAK (Figs. 70-72) (Piles).

OAK, INDIAN, *Barringtonia acutangula*, occurs

in India and Queensland. A fine-grained, hard, durable, red wood.

PINE, MORETON BAY (Cabinet making).

PLUM, SEBASTAN, *Cordia myxa*, also known as Nakkern Wood, occurs in India, Egypt, Arabia, Malay Peninsula and Persia. A coarse-grained, soft, but strong wood, easy to work. Light brown and greyish in colour.

RATA, *Meterosideros robusta*, also known as Northern Rata, occurs in New Zealand. A fine-grained, dense wood. Works well. Very durable, tough and strong. Heartwood uniform red-brown, sapwood paler brown.

ROSEWOOD, AUSTRALIAN, *Synoum glandulosum* (Fig. 68), also known as Brush Bloodwood, Dogwood, Bastard Rosewood. A fine-grained, dense, easily worked and polished wood. Dark red colour.

SABICU, *Lysiloma Sabicu*, occurs in West Indies. A fine-grained, durable wood. Strong, easily worked and polished. Red-brown.

SAJ (Paving).

SIRIS, PINK (Furniture).

SONARI (Carriage building).

SPRUCE, SITKA (Charcoal).

SUNDRI (Wheels).

TEAK, *Tectona grandis* (Fig. 31), also known as Indian Oak, occurs in Central and South India,

74 TIMBERS AND THEIR USES

Burma and North Borneo. A coarse, open-grained wood, with a surface greasy to the touch. "Almost imperishable in some climates." Does not suffer by contact with metals. Does not warp, split or crack. Colour—heartwood deep golden yellow, sapwood nearly white.

TEAK, BASTARD (Building).

TOOART, *Eucalyptus gomphocephala*, also known as Tuart, Tewart, White Gum, occurs in Western Australia. A fine, cross-grained wood, with a greasy surface. Strong and durable, not liable to warp or split. "The strongest and toughest wood in Western Australia." Very tough, not affected by weather or high temperature. Works moderately well. Heartwood yellowish, sapwood dull brown.

TULIP TREE (Fig. 16) (Building).

UMBRELLA TREE (Furniture).

WACAPOU (Sleepers).

WILLOW, CRACK (Cabinet making).

Sleepers. Timber used for sleepers must be exceptionally strong, capable of standing heavy loads, not affected by alternate wetting and drying and durable in contact with the soil.

ACLE (Piles).

ANJAN, *Hardwickia binata*, occurs in India. A close-grained, strong, durable, non-warping

timber. "Perhaps the hardest and heaviest wood in India." Colour deep red with black lines.

BALBUL (Wheels).

BANDARA, *Lagerstraemia parviflora*, var. *majuscula*, occurs in India. A tough, elastic, durable timber. Light brown.

BEECH (Fig. 56) (Charcoal).

BLACKBUTT (Fig. 6) (Wheels).

BLOODWOOD, *Eucalyptus corymbosa*, occurs in New South Wales and Queensland. Also known as Red Bloodwood. A straight, close-grained, durable timber. Subject to veins. "The most durable hard wood in Queensland, but its life as a sleeper is diminished by its tendency to shell off along the veins." Deep red in colour.

BULLET WOOD, ANDAMAN, *Mimusops littoralis*, occurs in Andaman Islands. A close-grained, hard, durable wood. Rather liable to split. Red-brown colour.

CANARY WOOD, *Eucalyptus hemiphloia*, also known as Gum-topped Box, White Gum, Australian Box, occurs in Australia. A very fine, open-grained, smooth-surfaced wood. Durable, though liable to insect attack. Yellowish grey in colour.

CEDAR, ATLAS, *Cedrus atlantica*, occurs in North West Africa. An even-grained, durable wood. Rich red colour. Pliny states that the

76 TIMBERS AND THEIR USES

beams of the Temple of Apollo at Utica, made of Numidian Cedar, were sound after 1,178 years.

CEDAR, DEODAR, *Cedrus Deodara*, also known as Indian Cedar, occurs in Central Asia. A very durable, even-grained, hard wood. Yellowish brown. "The pillars in the Shah Hamaden Mosque at Srinagar of this wood are probably over 400 years old, and some of the bridges in the same city, though their piers are alternately wet and dry, are said to have lasted even longer."

CEDAR, RED (Wheels).

CEDAR, ROCK, *Juniperus sabinoides*, occurs in Central America. A close-grained, hard, durable wood. Heartwood brown, sapwood white.

CEDAR, YELLOW, *Chamaecyparis nutkaensis*, also known as Sitka Cedar, Cypress, Yellow Cypress, occurs in Canada and United States. A soft, easily worked, but very durable wood. Heartwood light brown, sapwood nearly white.

CEDAR, WHITE, *Cupressus thyoides*, occurs in Eastern United States. A close-grained, light, soft, durable, easily worked wood. Grey-brown colour.

CYPRESS PINE (Piles).

CYPRESS, SWAMP, *Taxodium distichum* (Fig. 36), also known as Red Cypress, White Cypress, Black Cypress, Deciduous Cypress, Bald Cypress,

occurs in Southern United States. A straight, fine-grained, soft, durable wood. Reddish yellow when fresh cut, but becoming distinctly red on exposure to the air.

GUM, APPLE-SCENTED, *Eucalyptus Stuartiana*, also known as Woolly Butt, Box, Tea Tree, Turpentine, Peppermint Tree, Apple Tree, Red Gum, Mountain Ash, occurs in Eastern Australia. A sinuous-grained, hard, durable wood. Difficult to work, but takes a good polish. Brownish red.

GUM, MOUNTAIN, *Eucalyptus tereticornis* (Fig. 1), also known as Blue Gum, Slaty Gum, Red Gum, Grey Gum, Flooded Gum, Bastard Box, occurs in Eastern Australia. A cross-grained, heavy, hard, durable wood. Red-brown in colour.

GUM, NANKEEN, *Eucalyptus populifolia*, also known as White Gum, White Poplar, Red Poplar, Benbil Box. A close-grained, heavy, hard, strong, durable wood. Not easy to work, takes a good polish. Pale brown colour.

GUM, SLATY, *Eucalyptus largiflorens*, also known as Ironbark, Grey Box, Black Box, Yellow Box, Bastard Box, Cooburn Box, occurs in Australia. A close-grained, hard, durable, red wood.

GUM, SUGAR (Piles).

GUM, BROAD-LEAVED WATER, *Tristania*

suaveolens, also known as Mahogany, Swamp Mahogany, Bastard Peppermint, occurs in Eastern Australia. A close-grained, strong, hard, elastic, durable wood. Red colour.

HEMLOCK SPRUCE, *Tsuga canadensis*, also known as Hemlock, Hemlock Fir, occurs in Eastern North America. A coarse-grained, soft wood. Difficult to work and not too durable. Light brown in colour.

HINAN, *Elaeocarpus dentatus*, occurs in New Zealand. A very fine, close-grained, dense, dull-surfaced wood. Easily worked, very durable. Heartwood brown.

IROKO, *Chlorophora excelsa*, also known as Odum, occurs in West Africa. A coarse-grained, strong, durable wood. "This wood has probably a great future on the European market, being one of the finest known substitutes for Teak, which it resembles in colour, and, when sawn tangentially, in texture. Rich brown colour.

IRONBARK, GREY, *Eucalyptus paniculata*, also known as Bloodwood, Red Ironbark, White Ironbark, Pale Ironbark, She Ironbark, occurs in Eastern Australia. A very hard, strong, tough, durable wood. "The most valuable Ironbark." Works well. Brown.

IRONBARK, NARROW-LEAVED, *Eucalyptus crebra*, also known as Grey Ironbark, White Ironbark,

Red Ironbark, occurs in Eastern Australia. A cross-grained, heavy, hard, durable wood. Difficult to work. Dark brown.

JAMBOLANA, *Syzygium Jambolana*, occurs in India, Ceylon, Australia, Mauritius. A close-grained, hard, durable, red wood.

JARRAH (Paving).

KAURI, *Agathis australis* (Fig. 42), also known as Kauri Pine, Southern Dammar, Cowrie, Cowdie Pine, New Zealand Pine, New Zealand Pitch Tree, Kawri, occurs in New Zealand. A very fine, even, satiny-surfaced timber. Very durable and strong. Elastic, easily worked and polished. Pale yellow colour.

LAPACHO, *Tabebuia flavesceus*, occurs in Central South America. A close-grained, heavy, durable wood. Greenish brown in colour.

LARCH (Wheels).

LEATHER JACKET (Wheels).

LOCUST, BLACK (Fig. 23) (Wheels).

MAHWA (Wheels).

MIRABOW, *Afzelia palembanica*, also known as Meraban, Merban, occurs in Borneo, Malay Archipelago, Andaman Islands. An even-grained, hard, tough wood, easily worked and polished. Red-brown.

OAK (Figs. 70-72) (Piles).

OAK, ZEEN (Cooperage).

PINE, SILVER, *Dacrydium Westlandicum*, also

known as Westland Pine, Manao, occurs in New Zealand. A fine-grained, even, bright-surfaced wood. Works well, very strong and durable. Heartwood yellowish brown, sapwood nearly white.

PUIRI, *Vitex littoralis*, also known as New Zealand Teak, occurs in New Zealand. A fine, open-grained, lustrous wood. Very tough, durable and hard to work. "The strongest and most durable timber supplied by the Colony, and in order to split it, it needs blasting powder or dynamite." Heartwood greenish brown, sapwood yellowish.

RATA (Shipbuilding).

SAL, *Shorea robusta*, also known as Morung Sal, Saul, occurs in North and Central India. A coarse-grained, hard, elastic wood. Very durable and strong. Not attacked by insects on account of its resin. Heartwood brown with dark brown stripes, sapwood nearly white.

TAMARAK, *Larix americana*, also known as American Larch, Black Larch, Red Spruce, Hackmatack, occurs in Canada and United States. A fine-grained wood. Very strong and durable. Heartwood pale brown, sapwood nearly white.

TAMKAHA, *Phyllocladus trichomanoides*, also known as Celery-topped Pine, Celery-leaved Pine,

Celery Pine, Tanekaha, occurs in New Zealand. A fine-grained, hard, tough, durable wood. Easily worked. Heartwood pale brown, sapwood darker brown.

TOTARA (Piles).

TURPENTINE TREE (Fig. 34) (Piles).

WACAPOU, *Andira Aubletii*, also known as Acapu Backheart, occurs in Guiana. A straight-grained, durable, easily worked, dark brown wood.

WANDOO, *Eucalyptus redunca*, also known as White Gum, occurs in Western Australia. A heavy, hard, tough, durable, red-brown wood.

Telegraph poles. The requirements for Telegraph poles are very similar to those for masts. The timber must be straight growing, strong, capable of withstanding changes of climate, but, in addition, it should not be affected by contact with the soil.

ACLE (Piles).

BLACKBUTT (Fig. 6) (Wheels).

CEDAR ROCK (Sleepers).

JARRAH (Paving).

KAURI (Fig. 42) (Sleepers).

TAMARAK (Sleepers).

Turnery. Timber for turners' use should be hard and tough and capable of taking a high polish.

82 TIMBERS AND THEIR USES

ALMOND, WILD, *Brabejum stellatifolium*, also known as Wild Chestnut, Red Stinkwood, Amandelbloom, Caffre, occurs in South Africa. A strong, hard, durable wood.

ANGICO, *Piptadenia rigida*, also known as Queen wood, occurs in Brazil. A fine, open or close-grained, dense wood, of a red-brown colour, striped with black.

APPLE, *Pyrus malus* (Fig. 58), also called Crab, Crab Apple, Wild Apple, Crabtree, occurs in Europe, Western Asia, Northern India. A very fine, close-grained wood. Brittle, polishes well, but liable to warp. Heartwood pale red, sapwood brownish.

ASPEN (Pulp).

ASPEN, AMERICAN (Pulp).

BARRANDUNA, *Trochocarpa laurina*, also known as Myrtle, Beech Myrtle, Brush Myrtle, Cherry Myrtle, occurs in New South Wales and Queensland. A hard, tough, close-grained wood. Rich brown in colour.

BASSWOOD (Cooperage).

BEECH (Fig. 56) (Charcoal).

BIRCH (Charcoal).

BIRCH, CANOE (Pulp).

BIRCH, GREY (Carriage building).

BLACKWOOD (Figs. 7-10) (Musical Instruments).

BLACKWOOD, AFRICAN, *Dalbergia melanoxylon*

(Fig. 29), also known as Ebony, Senegal Ebony, African Grenadilla Wood, occurs in Tropical Africa. A coarse, even-grained wood, with a lustrous surface. Jet black in colour.

BOX (Fig. 61) (Engraving).

BOX, CAPE, *Buxus Macowani*, also known as East London Boxwood, occurs in South Africa. A smooth, fine-grained, dense timber. Yellowish in colour.

BUCKEYE (Pulp).

BUCKTHORN, *Rhamnus catharticus*, occurs in Europe, Northern Africa and Siberia. A hard, heavy, close-grained wood. Heartwood orange, sapwood yellowish green.

BUNYA-BUNYA, *Araucaria Bidwilli* (Fig. 38), also known as Bunya Pine, occurs in Queensland. A close, straight-grained, easily worked and polished timber. Very durable and does not warp. Yellow.

CANARY WOOD (Dyes).

CEDAR, RED (Wheels).

CHATWAN, *Alstonia scholaris*, occurs in India, Ceylon and Malacca. A coarse-grained, soft wood. White.

CHERRY (Miscellaneous).

COROMANDEL WOOD, *Diospyros quaesita*, also known as Calamander, occurs in Ceylon. A close-grained, dense, hard wood. Rich brown with black stripes.

CUCUMBER, TREE, *Magnolia acuminata*, also known as Mountain Magnolia, occurs in Eastern United States. A close-grained, soft, yet durable wood. Heartwood brownish yellow, sapwood white.

EBONY, FALSE, *Cytisus laburnum*, also known as Laburnum, occurs in Europe. A hard, close-grained, easily polished, non-durable wood. Heartwood brownish green, sapwood yellow.

ELM, ENGLISH (Carriage building).

ELM, SPREADING, *Ulmus effusa*, occurs in Europe. A close-grained wood with a pale brown heart and yellowish sapwood.

HALDU (Fig. 33) (Masts).

IRONWOOD, AUSTRALIAN, *Notelaea ligustrina* (Fig. 63), also known as Heartwood, Native Olive, White Plum, Spurious Olive, occurs in Australia and Tasmania. A very close-grained, hard, easily polished wood.

IVORY WOOD (Engraving).

JACK (Musical Instruments).

JUNIPER, *Juniperus communis*, occurs in Europe. A fine, smooth, close-grained, bright-surfaced wood. Very durable, easily worked. Reddish brown heartwood, yellowish white sapwood.

LIGNUM VITAE (Fig. 62) (Cogs).

LIME (Fig. 15) (Charcoal).

LOCUST, BLACK (Fig. 23) (Wheels).

MANZANITA, *Arctostaphylos pungens*, occurs in United States. A very fine, open-grained wood. Lustrous, works easily. Heartwood purple-red, sapwood white.

MAPLE (Fig. 57) (Charcoal).

MAPLE, NORWAY (Musical Instruments).

MAPLE, RED, *Acer rubrum*, also known as Swamp Maple, Soft Maple, Water Maple, occurs in Eastern United States and Canada. A close-grained, hard, elastic wood. Easily polished. Heartwood red-brown, sapwood pale brown.

MARBLE WOOD (Furniture).

MUSK TREE, *Marlea vitiensis*, occurs in Fiji. A close-grained timber, smelling of Musk. Heartwood black, sapwood yellow.

MUSK WOOD, *Olearia argophylla* (Fig. 64), occurs in South Eastern Australia. A hard, easily worked and polished wood, beautifully figured. Rich yellow in colour.

MYALL (Miscellaneous).

MYALL, BRIGALOW (Miscellaneous).

MYRTLE, SCRUB, *Backhousia myrtifolia*, also known as Grey Myrtle, Native Myrtle, Lancewood, occurs in Queensland. A hard, close-grained, durable wood. Yellow.

NETTLE TREE (Miscellaneous).

OAK, AFRICAN, *Lophira alata*, also known as Scrubby Oak, Laintlaintain, Millai, Meni, occurs

86 TIMBERS AND THEIR USES

in West Africa. A coarse, open-grained, lustrous wood. Deep red colour with white lines.

OAK, SHINGLE, *Casuarina stricta*, also known as River Oak, Salt Water Swamp Oak, Coast She Oak, occurs in South Eastern Australia. A very hard, close-grained, heavy wood. Easily worked, non-durable. Red coloured.

OLIVE, *Olea europea*, occurs in Mediterranean region. A very dense, even, smooth, dull-surfaced wood. Heartwood and sapwood yellowish.

OSAGE, ORANGE (Engraving).

PEAR, *Pyrus communis*, occurs in Europe and Western Asia. A fine-grained, dull-surfaced wood. Very durable, easily worked and polished. Reddish brown.

PEAR, WHITE, *Apodytes dimidiata*, also known as Wit Pear, occurs in South Africa. A very fine, close-grained, dull-surfaced wood. Works well, does not warp. Greyish brown, a sapwood tree.

PINE, BLACK (Piles).

PLANE, EASTERN (Cabinet making).

PLUM (Fig. 59) (Musical Instruments).

ROSEWOOD, BRAZILIAN (Musical Instruments).

ROWAN (Carving).

SERVICE (Engraving).

SILKBARK, *Celastrus acuminatus*, also known as Zybust, occurs in South Africa. An excep-

tionally fine-grained, dense wood. Dull surface. Not easy to work, but polishes well. Brown, marked with darker brown, resembling watered silk.

TAMARIND (Charcoal).

TONQUIN BEAN (Medicine).

TULIP TREE (Fig. 16) (Building).

VLIER, *Nuxia floribunda*, also known as Elder, occurs in South Africa. A very fine, close-grained wood, bright. Works easily and takes a good finish. Colour purplish red.

Wheels. Wood used for the various parts of wheels should be strong and elastic. Not liable to warp or to split.

APPLE, BROAD-LEAVED, *Angophora subvelutina*, occurs in Queensland and New South Wales. A durable, tough wood, reliable for wheels when properly seasoned. Reddish brown in colour.

APPLE, NARROW-LEAVED, *Angophora intermedia*, occurs in Eastern Australia. A tough, non-warping wood.

ASSEGAI WOOD (Carriage building). .

BALBUL, *Acacia arabica*, occurs in India. A hard, durable, pale red-brown wood.

BIRCH (Charcoal).

BIRCH, YELLOW, *Betula lutea*, also known as Grey Birch, Tall Birch, occurs in Eastern North

America. A close-grained, strong, durable, easily polished wood. Heartwood pale brown, sapwood almost white.

BLACKBUTT, *Eucalyptus patens* (Fig. 6), occurs in Western Australia. A fine, open-grained, durable wood. Heartwood brown, sapwood pale brown.

BOTTLEBRUSH, RED, *Callistemon lanceolatus*, also known as Water Gum, occurs in Eastern Australia. A hard, close-grained wood.

BOX, BASTARD (Shipbuilding).

BOX, RED, *Eucalyptus polyanthema*, also known as Bastard Box, Brown Box, Grey Box, Poplar-leaved Gum, Lignum Vitae, occurs in South Eastern Australia. A very fine-grained, hard, durable, red wood.

BOX, YELLOW (Fig. 61) (Engraving).

CANNON BALL TREE, *Xylocarpus granatum*, also known as Sea Coconut, occurs in Burma, Ceylon, Fiji Islands. A close-grained, hard, reddish white wood.

CEDAR, RED CAPE, *Cunonia Capensis*, occurs in Cape Colony. A close-grained, hard, tough, elastic wood. Easily polished. Red in colour.

CHERRY, AUSTRALIAN WILD, *Exocarpus cupressiformis* (Fig. 35), occurs in Australia. A close-grained, hard, durable wood. Red-brown in colour.

CURUPAY, *Piptadenia cebil*, occurs in Bolivia.

A coarse-grained, heavy, hard, durable, red wood.

ELM, AMERICAN (Fig. 51) (Cooperage).

ELM, CANADIAN (Carriage building).

GREENHEART (Piles).

GUAYACAN, *Caesalpinia melanocarpa*, occurs in Argentina. A close-grained, dense, heavy, dark brown wood. "Said to be the hardest wood in the country."

GUM, BLUE (Fig. 1) (Carriage building).

GUM, RED (Piles).

GUM, SALMON, *Eucalyptus salmonophloia*, also known as Salmon-barked Eucalyptus, Salmon-barked Jarrah, occurs in Western Australia. A very fine-grained, smooth, dull-surfaced wood. "Believed to be superior to any of the Western Australian timbers." Very durable and tough. Salmon coloured.

GUM, SUGAR (Piles).

HACKBERRY, *Celtis occidentalis*, also known as False Elm, Sugarberry, Nettle Tree, occurs in Eastern North America. A fine-grained, heavy, easily worked and polished wood. Heartwood brown, sapwood yellowish white.

HICKORY, SHELL-BARK, *Hicoria ovata*, also known as White Hickory, Shag-bark Hickory, occurs in Eastern United States. A coarse grained, durable, very elastic wood.

IRONBARK, GREY (Sleepers).

JARUL (Shipbuilding).

JHAND, *Prosopis spicigera*, occurs in Central Asia. A straight-grained, hard, strong, but non-durable wood. Deep brown in colour.

KARRI, *Eucalyptus versicolor*, also known as White Gum, Kari, Blue Gum, occurs in Western Australia. A coarse, open-grained, lustrous wood. Tough and elastic. Heartwood deep red, sapwood pale brown.

KIAMIL, *Odina Wodier* (Fig. 28), occurs in India, Ceylon, Burma. A close-grained, hard, non-durable wood. Red-brown in colour.

KIRTON WOOD, *Elaeocarpus Kirtoni* (Fig. 21), also known as Australian White Beech, occurs in New South Wales and Queensland. A fine, open-grained, lustrous wood, easy to work. Pale brown in colour.

KNOBTHORN, *Zanthoxylum capense*, also known as Knobhout, occurs in South Africa. A very fine, close-grained wood. Heartwood brown, sapwood greenish yellow.

KOSUM, *Schleichera trijuga*, also known as Ceylon Oak, occurs in Ceylon, India and Burma. A close-grained, heavy, hard, durable wood. Red in colour.

LAPACHE (Sleepers).

LARCH, *Larix europaea*, occurs in Northern Europe. A fine, even-grained wood. Very durable and tough. "Its durability rendered

Larch a favourite wood in ancient Rome. Augustus built his forum with it ; Tiberius brought this timber for the repair of bridges from the forests of Rhaetia and preserved one tree, which was 120 feet long and 2 feet in diameter throughout, as a curiosity ; and Vitruvius attributes the decay of the buildings erected in Rome at the time to the disuse of Larch on the exhaustion of the forests near the city." Heartwood red-brown, sapwood yellowish white.

LASRIN, *Albizzia odoratissima*, also known as Sweet-scented Mimosa, occurs in India, Ceylon and Burma. A coarse-grained, lustrous wood. Strong and durable. Polishes well. Heartwood banded brown and black, sapwood pinkish.

LEATHER JACKET, *Eucalyptus paniculata*, also known as Hickory, Bastard Box, Grey Gum, Red Gum, Yellow Gum, Turpentine, occurs in New South Wales. A close-grained, heavy, hard wood. Durable and tough. Heartwood red-brown, sapwood yellow.

LOCUST, *Robinia pseudacacia* (Fig. 23), also known as Black Locust, False Acacia, Yellow Locust, Red Locust, occurs in Europe and North America. A coarse, open-grained, lustrous wood. "Almost incorruptible, more durable than Oak." Elastic. Unrivalled for spokes. Heartwood greenish yellow, sapwood greenish white.

MAHOGANY, SWAMP (Shipbuilding).

MAHWA, *Illipe latifolia*, also known as Butter Tree, occurs in Northern India. A strong, tough wood of a rich red colour, used for the naves of wheels.

MAIRE, BLACK, *Olea Cunninghami*, occurs in New Zealand. A dense, close-grained, dull-surfaced wood. Very durable. "The strongest wood in the Dominion." Heartwood dark brown striped with black, sapwood pale brown striped with pink.

MANGO, *Mangifera indica*, occurs in the warmer parts of Asia, introduced into the West Indies. A fairly close-grained, hard, durable wood. "Holds a nail better than any other wood." Pale brown in colour.

MAPLE, ROCK (Shipbuilding).

MILKWOOD, RED, *Mimusops obovata*, occurs in South Africa. A close-grained, tough wood.

OAK, LIVE, *Quercus virens*, occurs in Southern United States. A close-grained, *tough, dense, strong wood. Difficult to work. Durable. "Stronger than any known Oak." Heartwood dark brown, sapwood pale brown.

OSAGE, ORANGE (Paving).

PEAR, RED, *Scolopia Mundtii*, also known as Thorn, Klipdoorn, occurs in South Africa. A fine, open-grained, dull-surfaced wood. Durable,

hard and easily worked. Heartwood red-brown, sapwood paler.

PEARWOOD, WHITE (Turnery).

SANDAN (Furniture).

SISSOO, *Dalbergia Sissoo*, occurs in Northern India. A close, even-grained wood. Very heavy, hard, elastic and durable. Does not warp or split. "Unrivalled for the naves and felloes of wheels." Dark rich red in colour.

STRINGY BARK, *Eucalyptus macrorrhyncha*, also known as Ironbark, occurs in South East Australia. A close-grained, strong, elastic wood. Durable. Takes a good polish. Heartwood pale brown figured with darker brown.

SUNDRI, *Heritiera fomes*, occurs in Bengal, Borneo and Malay Peninsula. A very hard, tough, elastic, durable wood. Excellent for spokes, naves and felloes. Brown in colour.

TALLOW WOOD (Fig. 67) (Paving).

TEAK, AFRICAN, *Oldfieldia africana*, also known as African Oak, occurs in Tropical Africa. A fine, open-grained, bright-surfaced wood. Very strong, durable and easily worked. Dark brown. Not a true Teak.

WALNUT, AMERICAN (Fig. 54) (Cabinet making).

WALNUT, BLACK (Fig. 55) (Cabinet making).

WALNUT, EAST INDIAN (Building).

WOOLLY BUTT, *Eucalyptus longifolia*, also

known as Bastard Box, occurs in South East Australia. A close-grained, hard, heavy wood. Very durable. Used for felloes and spokes. Dark red in colour.

YEN DIKE, *Dalbergia cultrata*, also known as Blackwood, occurs in Burma. A close-grained, heavy, hard, elastic and very durable wood. Used for spokes. Colour "black with white and red stripes."

Miscellaneous Timbers.

ACAJOU, *Cedrela guianensis*, occurs in French Guiana. A soft, durable, easily worked wood. Used for making cigar boxes.

ALDER, *Alnus glutinosa* (Fig. 24), also known as Black Alder, Common Alder, occurs in Europe. A very fine, even-grained, bright-surfaced wood. Very durable and elastic. Sapwood pale red-brown, a sapwood tree. Largely used for making clogs. The best wood for gunpowder charcoal.

ASH, *Fraxinus excelsior* (Fig. 49), also known as Common Ash, Hungarian Ash, occurs in Europe and North Africa. An open-grained, bright-surfaced wood. Tough and elastic, does not warp. Durable. Heartwood yellowish brown, sapwood white. Ash wood is put to more uses than any other, among which may be mentioned: Wheels, carriage building, lance

poles, agricultural implements, furniture, chopping blocks, croquet mallets, billiard cues.

ASPEN, *Populus tremula*, occurs in Europe. A fine-grained, soft, elastic wood. Not given to warping. Used for clogs, pack saddles, etc.

BASSWOOD, *Tilia americana*, also known as Lime Tree, Willow, Linden, Lin, Bec Tree, occurs in North America. A very fine, open-grained, beautifully lustrous wood. Soft, easily worked but durable. Cream coloured. Used for toys, cheap furniture, ply wood.

BEATI, *Cassia siamea*, also known as Rosewood, Bombay Blackwood, occurs in India, Ceylon and Burma. A close-grained, hard, black wood. Used for walking-sticks and mallets.

BLACKTHORN, *Prunus spinosa*, also known as Sloe, occurs in Europe. A fine-grained, tough wood. Heartwood dark brown, sapwood reddish. Used for walking-sticks.

BRIAR ROOT, *Erica arborea*, occurs in Southern Europe. A small, close-grained wood. Colour mottled dark and light brown. Used for making tobacco pipes.

CAROB, *Ceratonia siliqua*, also known as Locust Bean, St. John's Bread. Used for making walking-sticks.

CEDAR, *Cedrela odorata* (Fig. 25), also known as Cigar Box Cedar, Havannah Cedar, Barbados Bastard Cedar, Cuba Cedar, Honduras Cedar,

Mexican Cedar, Jamaica Cedar, West Indian Cedar, occurs in West Indies and Tropical America. A coarse, open-grained wood. Brittle. Used for making cigar boxes for good quality cigars. Heartwood red-brown, sapwood nearly white.

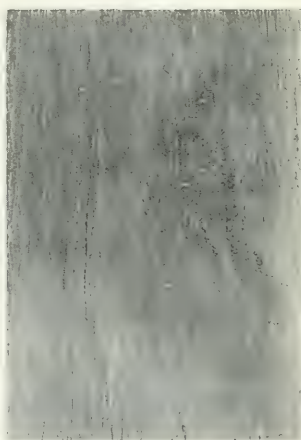
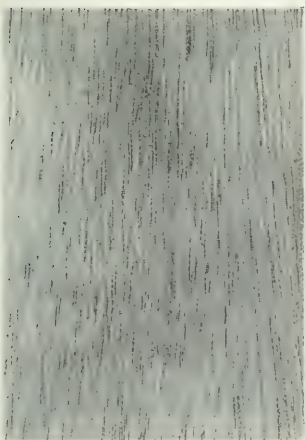
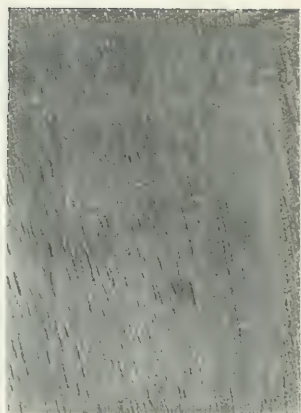
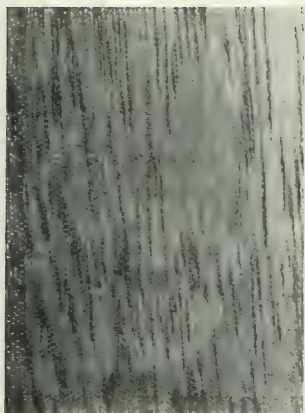
CEDAR, PENCIL, *Juniperus virginiana*, also known as Red Cedar, Virginian Cedar, occurs in Canada and United States. A very fine, even-grained wood. Durable. Easily polished. Heartwood rich red, sapwood white. Used for making pencils.

CHERRY, *Prunus cerasus*, also known as Garden Cherry, Sour Cherry, occurs in Europe and North America. A close-grained, lustrous wood. Heartwood light or dark brown, sapwood reddish white. Used for making tobacco pipes.

MYALL, *Acacia pendula*, also known as Weeping Myall, Boree, Violet-wood, True Myall, occurs in Victoria, New South Wales and Queensland. A fine, sinuous-grained wood with a bright surface. Very dark brown. Used for making tobacco pipes, boomerangs, etc.

MYALL, BRIGALOW, *Acacia harpophylla*, also known as Brigalow, occurs in Queensland. A straight, coarse-grained wood, with a bright surface. Elastic. Heartwood brown, sapwood white. Used for tobacco pipes, boomerangs, etc.

NETTLE, TREE, *Celtis australis*, occurs in the



17. AUSTRALIAN MOUNTAIN ASH.

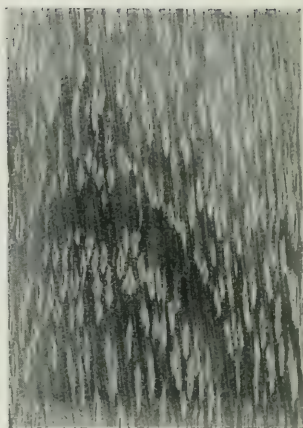
18. PENCIL CEDAR.

19. CAIRN'S PENCIL CEDAR.

20. RED CEDAR.



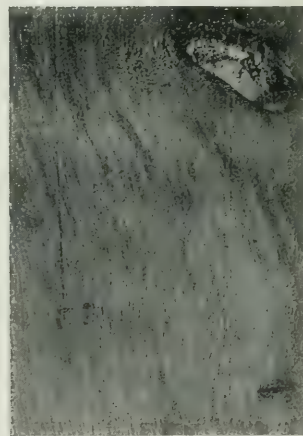
21. AUSTRALIAN WHITE BEECH.



22. BEAN.



23. LOCUST.



24. ALDER.

Mediterranean region. A close-grained, hard, elastic wood. Easily polished. Yellowish in colour. Used for whip handles, flutes, walking-sticks, etc.

PIN BUSH, *Hakea leucoptera*, also known as Needle Bush, Water Tree, Beefwood, occurs in Central and Eastern Australia. A coarse-grained, soft, easily polished wood. Used for making tobacco pipes.

PORCUPINE WOOD, *Cocos nucifera*, occurs in India. A palm whose wood is used for walking-sticks, spears, etc.

SYCAMORE, *Acer Pseudo-Platanus*, occurs in Europe, North America. A fine even-grained wood. Easily worked and polished. Quite white, a sapwood tree. Used for table tops, shop boards, etc., on account of its whiteness.

WILLOW, WHITE, *Salix alba*, occurs in Europe, North Africa, North West India and Northern and Western Asia. An even, straight-grained wood. Heartwood pale brown, sapwood white. Used for making cricket-bats.

CHAPTER II

GEOGRAPHICAL DISTRIBUTION

ANYTHING approaching a complete revision of the Geographical Distribution of the World's Timber trees would fill a volume larger than the present one. We can afford the space for but a brief outline of the subject. Geographical Distribution, in the case of plants, confronts the investigator with many perplexing problems. In the first place man himself has done much to complicate matters by introducing trees into various parts of the world to which they are not native; the Mango, an Asiatic tree, is a case in point, for it has been introduced into the West Indies. Again, there are other trees which are apparently native to widely separated countries, and how they have come to possess so scattered a range has led to many theories, some plausible, others by no means so.

There are trees again, such as the Tamarind, which occur practically everywhere throughout the tropics, and this brings us face to face with an important fact in connection with distribu-

tion. The whole matter depends largely upon climate. Thus we find Conifers for the most part in North America and in Europe; the Eucalypti or Gums in Australia, though it is true that they thrive in other parts of the world, where they have been introduced, notably in South Africa. In short, the mountain slope, the tropical forest, the wind-swept sea shore and the arid semi-desert, all have a vegetation peculiar to themselves and in all parts of the world, where the conditions are similar, the trees bear a strong family resemblance to one another.

The timber trees we mentioned in the previous chapter have been here separated geographically, not according to the latest tenets of the science, for that would entail considerable space, but approximately into continents.

The African trees comprise :—

Alder, White Cape	<i>Platylophus trifolius</i>
Almond, Wild	<i>Brabejum stellatifolium</i>
Ash	<i>Fraxinus excelsior</i>
Ash, Cape	<i>Ekebergia capensis</i>
Assegai Wood	<i>Curtisia faginea</i>
Birch, Cape	<i>Myrsine melanophleas</i>
Box, Cape	<i>Buxus Macowani</i>
Buckthorn	<i>Rhamnus catharticus</i>
Buckthorn, Alder	<i>Rhamnus frangula</i>
Camwood	<i>Baphia nitida</i>
Canarywood	<i>Morinda citrifolia</i>

100 TIMBERS AND THEIR USES

Carob	<i>Ceratonia siliqua</i>
Cashew	<i>Anacardium occidentale</i>
Cedar, Atlas	<i>Cedrus atlantica</i>
Cedar, Red Cape	<i>Cunonia capensis</i>
Els	<i>Rhus Thunbergii</i>
Hawthorn	<i>Crataegus oxyacantha</i>
Iroko	<i>Chlorophora excelsa</i>
Ironwood	<i>Sideroxylon inerme</i>
Ironwood, Cape	<i>Olea laurifolia</i>
Kamassi	<i>Gonioma Kamassi</i>
Knobthorn	<i>Zanthoxylum capense</i>
Milkwood, Red	<i>Mimusops obovata</i>
Monkey Pot	<i>Lecythis grandiflora</i>
Mopane	<i>Copaifera mopane</i>
Oak, African	<i>Lophira alata</i>
Oak, Zeen	<i>Quercus Mibeckii</i>
Pear, Hard	<i>Olinia cymosa</i>
Pear, Red	<i>Scolopia Ecklonii</i>
Pear, White	<i>Pterocelastrus rostratus</i>
Plum, Sebastan	<i>Cordia myxa</i>
Quar	<i>Euclea undulata</i>
Rosewood	<i>Pterocarpus erinaceus</i>
Rosewood, Canary	<i>Convolvulus scoparius</i>
Saffron Wood	<i>Eleodendron croceum</i>
Saliewood	<i>Buddelia salvifolia</i>
Silkbark	<i>Celastrus acuminatus</i>
Siris, Pink	<i>Albizzia fulibrissin</i>
Sneezewood	<i>Pteroxylon utile</i>
Spindle	<i>Euonymus europaeus</i>

GEOGRAPHICAL DISTRIBUTION 101

Stinkwood	<i>Ocotea bullata</i>
Tamarind	<i>Tamarindus indica</i>
Teak, African	<i>Oldfieldia africana</i>
Thuya	<i>Tetraclinis articulata</i>
Vlier	<i>Nuxia floribunda</i>
Walnut, East Indian	<i>Albizzia Lebbek</i>
Willow, White	<i>Salix alba</i>
Yellow Wood, Real	<i>Podocarpus Thunbergii</i>

The North American trees comprise :—

Apple	<i>Pyrus malus</i>
Apple, Oregon Crab	<i>Pyrus rivularis</i>
Ash, American	<i>Fraxinus Americana</i>
Ash, Blue	<i>Fraxinus quadrangulata</i>
Ash, Oregon	<i>Fraxinus oregona</i>
Ash, Red	<i>Fraxinus pennsylvanica</i>
Aspen, American	<i>Populus tremuloides</i>
Basswood	<i>Tilia americana</i>
Beech	<i>Fagus sylvatica</i>
Beech, American	<i>Fagus ferruginea</i>
Birch	<i>Betula alba</i>
Birch, Canoe	<i>Betula papyrifera</i>
Birch, Cherry	<i>Betula lenta</i>
Birch, Old Field	<i>Betula populifera</i>
Birch, Yellow	<i>Betula lutea</i>
Buckeye, Ohio	<i>Aesculus glabra</i>
Buckthorn, Canadian	<i>Rhamnus purshiana</i>
Catalpa	<i>Catalpa speciosa</i>

102 TIMBERS AND THEIR USES

Cedar, Canoe	<i>Thuja gigantissima</i>
Cedar, Incense	<i>Libocedrus decurrens</i>
Cedar, Oregon	<i>Cupressus Lawsoniana</i>
Cedar, Pencil	<i>Juniperus virginiana</i>
Cedar, White	<i>Cupressus thyoides</i>
Cedar, Yellow	<i>Cupressus nutkaensis</i>
Cherry	<i>Prunus cerasus</i>
Cherry, Wild Black	<i>Prunus serotina</i>
Chestnut	<i>Castanea vulgaris</i>
Chestnut, Horse	<i>Aesculus hippocastaneum</i>
Coffee Tree	<i>Gymnocladus canadensis</i>
Cucumber Tree	<i>Magnolia acuminata</i>
Cypress, Swamp	<i>Taxodium distichum</i>
Dogwood, American	<i>Cornus florida</i>
Elm, American	<i>Ulmus americana</i>
Elm, Canadian	<i>Ulmus racemosa</i>
Elm, Moose	<i>Ulmus fulva</i>
Fir, Balsam	<i>Abies balsama</i>
Fir, Great	<i>Abies grandis</i>
Gum, Sweet	<i>Liquidambar styraciflua</i>
Hackberry	<i>Celtis occidentalis</i>
Hemlock Spruce	<i>Tsuga canadensis</i>
Hickory	<i>Carya sp.</i>
Laurel, Madrona	<i>Arbutus Menziesii</i>
Locust	<i>Robinia pseudacacia</i>
Magnolia, Large- flowered	<i>Magnolia grandiflora</i>
Manzanita	<i>Arctostaphylos pungens</i>
Maple, Oregon	<i>Acer macrophyllum</i>

GEOGRAPHICAL DISTRIBUTION 103

Maple, Red	<i>Acer rubrum</i>
Maple, Rock	<i>Acer barbatum</i>
Maple, Silver	<i>Acer saccharinum</i>
Mesquite	<i>Prosopis juliflora</i>
Mulberry, Red	<i>Morus rubra</i>
Oak, Basket	<i>Quercus Michauxii</i>
Oak, Californian	
Live	<i>Quercus chrysolepis</i>
Oak, Chinquapin	<i>Quercus Muhlenbergii</i>
Oak, Live	<i>Quercus virens</i>
Oak, Red	<i>Quercus rubra</i>
Oak, Yellow	<i>Quercus tinctoria</i>
Osage, Orange	<i>Maclura aurantiaca</i>
Pine, Hickory	<i>Pinus pungens</i>
Pine, Long-leaf	<i>Pinus palustris</i>
Pine, Oregon	<i>Pseudotsuga Douglasii</i>
Pine, Pitch	<i>Pinus rigida</i>
Pine, Sugar	<i>Pinus Lambertiana</i>
Pine, White	<i>Pinus strobus</i>
Plane, Western	<i>Platanus occidentalis</i>
Plum	<i>Prunus domestica</i>
Poplar, Balsam	<i>Populus balsamifera</i>
Poplar, Black	<i>Populus monilifera</i>
Poplar, Large-toothed	<i>Populus grandidentata</i>
Redwood,	
Californian	<i>Sequoia sempervirens</i>
Rowan	<i>Pyrus acuparia</i>
Spruce, Black	<i>Picea nigra</i>

104 TIMBERS AND THEIR USES

Spruce, Red	<i>Picea rubra</i>
Spruce, Sitka	<i>Picea sitchensis</i>
Sycamore	<i>Acer pseudo-platanus</i>
Tamarak	<i>Larix pendula</i>
Tulip Tree	<i>Liriodendron tulipifera</i>
Walnut, American	<i>Juglans nigra</i>
Willow, Black	<i>Salix nigra</i>

The trees of South and Central America, including the West Indies, comprise :—

Acajou	<i>Cedrela guianensis</i>
Acle	<i>Xylia dolabriformis</i>
Angelin	<i>Andira inermis</i>
Angelique	<i>Dicorynia paraensis</i>
Angico	<i>Piptadenia rigida</i>
Box, Jamaica	<i>Tecoma pentaphylla</i>
Brazil Wood	<i>Caesalpina brasiliensis</i>
Canelle	<i>Nectandra mollis</i>
Cedar	<i>Cedrela odorata</i>
Cedar, Guiana	<i>Icica altissima</i>
Cedar, Rock	<i>Juniperus sabinoides</i>
Chaire, Bois	<i>Tecoma leucoxydon</i>
Cirouaballi, Yellow	<i>Nectandra pisi</i>
Coco Wood	<i>Bocoa provocensis</i>
Cocobola Wood	Species unknown
Cogwood	<i>Ceanothus chloroxydon</i>
Crabwood	<i>Carapa guianensis</i>
Curupay	<i>Piptadenia cebil</i>

Cypre, Bois de	<i>Cordia gerascanthus</i>
Ebony, American	<i>Brya ebenus</i>
Ebony, Cuban	<i>Diospyros tetrasperma</i>
Fustic	<i>Chlorophora tinctoria</i>
Granadillo	<i>Amyris balsamifera</i>
Greenheart	<i>Nectandra rodioei</i>
Grignon	<i>Bucida angustifolia</i>
Grignon fou	<i>Qualea caerulea</i>
Guarabu	<i>Terminalia acuminata</i>
Gum, Sweet	<i>Liquidambar styraciflua</i>
Guayacan	<i>Caesalpina melanocarpa</i>
Hooboballi	<i>Stryphnodendron guianense</i>
Jack	<i>Artocarpus integrifolia</i>
Lapacho	<i>Tabebuia flavescens</i>
Laurel, Madrona	<i>Arbutus Menziesii</i>
Lignum Vitae	<i>Ixora ferrea</i>
Logwood	<i>Haematoxylon</i> <i>campechianum</i>
Molavé	<i>Vitex altissima</i>
Monkey Pot	<i>Lecythis grandiflora</i>
Mora	<i>Dimorphandra excelsa</i>
Nogal	<i>Juglans australis</i>
Pacara	<i>Enterolobium timbuova</i>
Palisander Wood	<i>Jacaranda brasiliana</i>
Panacoco	<i>Robinia panacoco</i>
Purple Heart	<i>Copaifera pubiflora</i>
Quassia	<i>Picraena excelsa</i>
Quinine	<i>Cincona calisaya</i>
Rosewood	<i>Dalbergia nigra</i>

106 TIMBERS AND THEIR USES

Rubber	<i>Hevea brasiliensis</i>
Sabicu	<i>Lysiloma sabicu</i>
Sapodilla	<i>Achras sapota</i>
Satinwood	<i>Chloroxylon swietenia</i>
Switch Sorrel	<i>Dodonaea viscosa</i>
Tamarind	<i>Tamarindus indica</i>
Tarco	<i>Thouinia Weinmannifolia</i>
Tonquin Bean	<i>Coumarouna odorata</i>
Tulip Wood	<i>Harpullia pendula</i>
Zebra Wood	<i>Connarus guianensis</i>

The Asiatic timbers thus comprise :—

Acle	<i>Xylia dolabriformis</i>
Akagashi	<i>Quercus acuta</i>
Anan	<i>Fagraea fragrans</i>
Angelly	<i>Artocarpus hirsuta</i>
Anjan	<i>Hardwickia binata</i>
Apple	<i>Pyrus malus</i>
Arjun	<i>Terminalia Arjuna</i>
Bakula	<i>Mimusops elengi</i>
Balbul	<i>Acacia arabica</i>
Bandara	<i>Lagerstraemia parviflora</i>
Bead Tree	<i>Melia composita</i>
Beati	<i>Cassia siamea</i>
Birch	<i>Betula alba</i>
Box	<i>Buxus sempervirens</i>
Buckthorn	<i>Rhamnus catharticus</i>
Buckthorn, Alder	<i>Rhamnus frangula</i>

GEOGRAPHICAL DISTRIBUTION 107

Bullet Wood	<i>Mimusops globosa</i>
Camphor	<i>Cinnamomum camphora</i>
Camphor Nepal	<i>Cinnamomum glanduliferum</i>
Canary Wood	<i>Morinda citrifolia</i>
Cannon Ball	<i>Xylocarpus granatum</i>
Cashew	<i>Anacardium occidentale</i>
Cedar, Deodar	<i>Cedrus Deodara</i>
Cedar, Moulmein	<i>Cedrela Toona</i>
Champak	<i>Michelia Champaca</i>
Chaplash	<i>Artocarpus Chaplasha</i>
Chatwan	<i>Alstonia scholaris</i>
Chir	<i>Pinus longifolia</i>
Chittagong Wood	<i>Chukrasia tabularis</i>
Coromandel Wood	<i>Diospyros quaesita</i>
Del	<i>Artocarpus nobilis</i>
Dogwood	<i>Cornus sanguinea</i>
Eagle Wood	<i>Aquillaria Agallocha</i>
Ebony, Bombay	<i>Diospyros ebenum</i>
Gamboge	<i>Garcinia Hanburyi</i>
Haldu	<i>Adina cordifolia</i>
Harra	<i>Terminalia Chebula</i>
Hawthorn	<i>Crataegus oxyacantha</i>
Hiba	<i>Thujopsis dolabrata</i>
Hinoki	<i>Cupressus obtusa</i>
Hornbeam	<i>Carpinus betulus</i>
Indigo	<i>Indigofera tinctoria</i>
Ironwood, Borneo	<i>Eusideroxylon Zwageri</i>
Ironwood, Indian	<i>Mesua ferrea</i>
Jack	<i>Artocarpus integrifolia</i>

108 TIMBERS AND THEIR USES

Jambolana	<i>Syzygium Jambolana</i>
Jarul	<i>Lagerstraemia flos-reginae</i>
Jhand	<i>Prosopis spicigera</i>
Kaya	<i>Torreyia nucifera</i>
Keyaki	<i>Zelkova acuminata</i>
Kiamil	<i>Odina Wodier</i>
Kizi	<i>Paulownia imperialis</i>
Kosum	<i>Schleichera trijuga</i>
Lasrin	<i>Albizzia odoratissima</i>
Loquat	<i>Eriobotrya japonica</i>
Mahogany, East Indian	<i>Soyimida febrifuga</i>
Mahwa	<i>Illipe latifolia</i>
Mango	<i>Mangifera indica</i>
Mangosteen	<i>Sandoricum indicum</i>
Marble Wood, Andaman	<i>Diospyros Kurzii</i>
Margosa	<i>Azadirachta indica</i>
Meranti	<i>Hopea Maranti</i>
Mirabow	<i>Afzelia palembanica</i>
Mulberry	<i>Morus alba</i>
Oak, Brown	<i>Quercus semicarpifolia</i>
Oak, Indian	<i>Barringtonia acutangula</i>
Oak, Turkey	<i>Quercus cerris</i>
Pader	<i>Stereospermum chelonoides</i>
Padouk	<i>Pterocarpus indicus</i>
Pai Cha	<i>Euonymus europaeus</i> , var. <i>Hamiltonianus</i>
Pear	<i>Pyrus communis</i>

GEOGRAPHICAL DISTRIBUTION 109

Piney Varnish	<i>Vateria indica</i>
Plum	<i>Prunus domestica</i>
Plum, Sebastan	<i>Cordia myxa</i>
Porcupine Wood	<i>Cocos nucifera</i>
Rowan	<i>Pyrus aucuparia</i>
Saj	<i>Terminalia tomentosa</i>
Sal	<i>Shorea robusta</i>
Sandalwood	<i>Santalum album</i>
Sandan	<i>Ougeinia dalbergioides</i>
Sanders Wood, Red	<i>Pterocarpus santalinus</i>
Sappan Wood	<i>Caesalpina sappan</i>
Siris, Pink	<i>Albizzia fulibrissin</i>
Sissoo	<i>Dalbergia sissoo</i>
Spindle	<i>Enonymus europaeus</i>
Sugi	<i>Cryptomeria japonica</i>
Sundri	<i>Heritiera fomes</i>
Switch Sorrel	<i>Dodonaea viscosa</i>
Tamarind	<i>Tamarindus indica</i>
Teak, Bastard	<i>Pterocarpus marsupium</i>
Thitka	<i>Pentace burmanica</i>
Tree of Heaven	<i>Ailanthus glandulosa</i>
Umbrella Tree	<i>Thespesia populnea</i>
Walnut, East	<i>Albizzia Lebbeck</i>
Indian	
Willow, Crack	<i>Salix fragilis</i>
Willow, White	<i>Salix alba</i>
Yen Dike	<i>Dalbergia cultrata</i>
Yenju	<i>Sophora japonica</i>
Yew	<i>Taxus baccata</i>

110 TIMBERS AND THEIR USES

The Australian timbers thus comprise :—

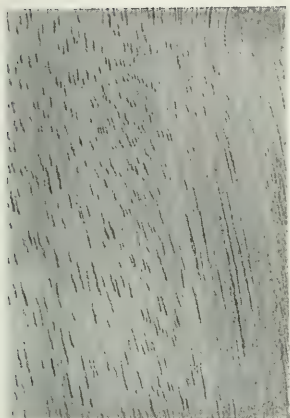
Acacia	<i>Eucryphia Moorei</i>
Apple, Black	<i>Sideroxylon australe</i>
Apple, Broad-leaved	<i>Angophora subvelutina</i>
Apple, Narrow-leaved	<i>Angophora intermedia</i>
Ash, Blueberry	<i>Elaeocarpus cyaneus</i>
Ash, Brush	<i>Acronychia Baueri</i>
Bally Gum	<i>Litsaea reticulata</i>
Banksia	<i>Banksia littoralis</i>
Barrandurra	<i>Trochocarpa laurina</i>
Bead Tree	<i>Melia composita</i>
Beech, Evergreen	<i>Fagus Cunninghamii</i>
Beech, She	<i>Cryptocarya glaucescens</i>
Beefwood	<i>Grevillea striata</i>
Birch, Black	<i>Fagus solandri</i>
Blackbutt	<i>Eucalyptus pilularis</i>
Blackwood	<i>Acacia melanoxylon</i>
Bloodwood	<i>Eucalyptus corymbosa</i>
Bottlebrush, Red	<i>Callistemon lanceolatus</i>
Box, Scrub	<i>Tristania conferta</i>
Box, Yellow	<i>Eucalyptus melliodora</i>
Bunya-bunya	<i>Araucaria Bidwilli</i>
Cajeput	<i>Melaleuca leucadendron</i>
Canarywood	<i>Eucalyptus hemiphloia</i>
Cedar, Australian	<i>Cedrela Toona</i>
Cedar, Bastard	<i>Dysoxylon rufum</i>
Pencil	
Cedar, Tasmanian	<i>Arthrotaxis selaginoides</i>

GEOGRAPHICAL DISTRIBUTION 111

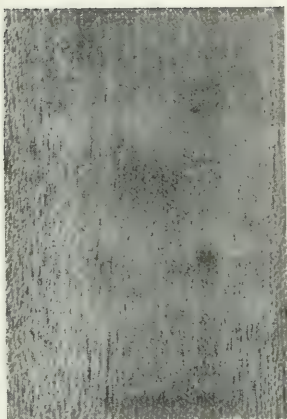
Chestnut, Moreton Bay	<i>Castanospermum australe</i>
Coachwood	<i>Ceratopetalum apetalum</i>
Cypress Pine	<i>Frenela robusta</i>
Gum, Apple-scented	<i>Eucalyptus Stuartiana</i>
Gum, Blue	<i>Eucalyptus globulus</i>
Gum, Broad-leaved	<i>Tristania suaveolens</i>
Water	
Gum, Cabbage	<i>Eucalyptus siberiana</i>
Gum, Cider	<i>Eucalyptus Gunnii</i>
Gum, Gimlet	<i>Eucalyptus salubris</i>
Gum, Mountain	<i>Eucalyptus tereticornis</i>
Gum, Nankeen	<i>Eucalyptus populifolia</i>
Gum, Red	<i>Eucalyptus rostrata</i>
Gum, Salmon	<i>Eucalyptus salmonophloia</i>
Gum, Scribbly	<i>Eucalyptus haemastoma</i>
Gum Slaty	<i>Eucalyptus largiflorens</i>
Gum, Spotted	<i>Eucalyptus maculata</i>
Gum, Sugar	<i>Eucalyptus corynocalyx</i>
Gum, Water	<i>Tristania neriifolia</i>
Hinau	<i>Elaeocarpus dentatus</i>
Ironbark, Grey	<i>Eucalyptus paniculata</i>
Ironbark, Narrow-leaved	<i>Eucalyptus crebra</i>
Ironbark, Red	<i>Eucalyptus siderophloia</i>
Ironwood	<i>Acacia excelsa</i>
Ironwood, Australian	<i>Acacia stenophylla</i>
Ivorywood	<i>Siphonodon australe</i>

112 TIMBERS AND THEIR USES

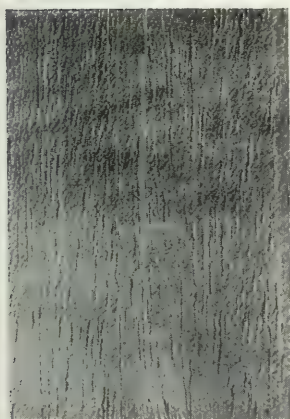
Jack, Long	<i>Flindersia Oxleyana</i>
Jambolana	<i>Syzygium Jambolana</i>
Jarrah	<i>Eucalyptus marginata</i>
Juniper, Australian	<i>Myoporum serratum</i>
Karri	<i>Eucalyptus diversicolor</i>
Kauri	<i>Agathis australis</i>
Kirton Wood	<i>Alphitonia excelsa</i>
Kohe Kohe	<i>Dysoxylon spectabile</i>
Kowhai	<i>Sophora tetraptera</i>
Lacebark	<i>Hoheria populnea</i>
Leatherjacket	<i>Eucalyptus paniculata</i>
Mahogany, Red	<i>Eucalyptus resinifera</i>
Mahogany, Swamp	<i>Eucalyptus robusta</i>
Maire, Black	<i>Olea Cunninghamii</i>
Myall	<i>Acacia pendula</i>
Myall, Brigalow	<i>Acacia harpophylla</i>
Myrtle, Red	<i>Eugenia myrtifolia</i>
Myrtle, Scrub	<i>Backhousia myrtifolia</i>
Myrtle, White	<i>Myrtus acmenioides</i>
Oak, Forest	<i>Casuarina glauca</i>
Oak, She	<i>Casuarina Fraseriana</i>
Oak, Shingle	<i>Casuarina stricta</i>
Oak, Silky	<i>Stenocarpus salignus</i>
Pin, Bush	<i>Hakea leucoptera</i>
Pine, Black	<i>Prumnopitys spicata</i>
Pine, Dundatha	<i>Agathis robusta</i>
Pine, Moreton Bay	<i>Araucaria Cunninghamii</i>
Pine, Silver	<i>Dacrydium Westlandicum</i>
Plum	<i>Prunus domestica</i>



25. CEDAR.



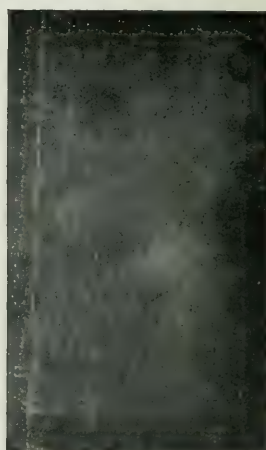
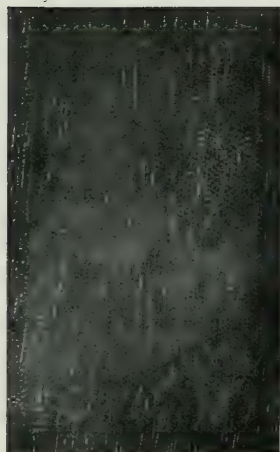
26. AFRICAN MAHOGANY.



27. CUBAN MAHOGANY.



28. KIAMIL.



29. BLACKWOOD.

31. TEAK.

30. GREEN EBONY.

32. MANGEAO.

GEOGRAPHICAL DISTRIBUTION 113

Plum, Sour	<i>Owenia venosa</i>
Puri	<i>Vitex littoralis</i>
Queenwood	<i>Davissia arborea</i>
Rata	<i>Meterosideros robusta</i>
Rewa-rewa	<i>Rymandra excelsa</i>
Rimu	<i>Dacrydium cupressinum</i>
Rosewood,	<i>Synoum glandulosum</i>
Australian	
Stringybark	<i>Eucalyptus obliqua</i>
Tallow Wood	<i>Eucalyptus microcorys</i>
Tamkaha	<i>Phyllocladus trichomanoides</i>
Tooart	<i>Eucalyptus gomphocephala</i>
Totara	<i>Podocarpus Totara</i>
Tulipwood	<i>Physocalymnia scaberrimum</i>
Turnip Wood	<i>Synoum glandulosum</i>
Turpentine Tree	<i>Syncarpia laurifolia</i>
Wandoo	<i>Eucalyptus redunca</i>
Woollybutt	<i>Eucalyptus longifolia</i>

The European timbers thus comprise :—

Alder	<i>Alnus glutinosa</i>
Apple	<i>Pyrus malus</i>
Ash	<i>Fraxinus excelsior</i>
Aspen	<i>Populus tremula</i>
Beech	<i>Fagus sylvatica</i>
Birch	<i>Betula alba</i>
Blackthorn	<i>Prunus spinosa</i>
Box	<i>Buxus sempervirens</i>

114 TIMBERS AND THEIR USES

Briar Root	<i>Erica arborea</i>
Buckthorn	<i>Rhamnus catharticus</i>
Buckthorn, Alder	<i>Rhamnus frangula</i>
Cherry	<i>Prunus cerasus</i>
Chestnut	<i>Castanea vulgaris</i>
Chestnut, Horse	<i>Aesculus hippocastaneum</i>
Dogwood	<i>Cornus sanguinea</i>
Ebony, False	<i>Cytisus laburnum</i>
Elm, English	<i>Ulmus campestris</i>
Elm, Spreading	<i>Ulmus effusa</i>
Elm, Wych	<i>Ulmus montana</i>
Fir, Silver	<i>Abies grandis</i>
Hawthorn	<i>Crataegus oxyacantha</i>
Hornbeam	<i>Carpinus betulus</i>
Juniper	<i>Juniperus communis</i>
Larch	<i>Larix europaea</i>
Locust	<i>Robinia pseudacacia</i>
Maple	<i>Acer campestre</i>
Maple, Norway	<i>Acer platanoides</i>
Mulberry	<i>Morus alba</i>
Nettle Tree	<i>Celtis australis</i>
Oak	<i>Quercus robur</i>
Oak, Kermes	<i>Quercus coccifera</i>
Oak, Turkey	<i>Quercus cerris</i>
Olive	<i>Olea europea</i>
Pear	<i>Pyrus communis</i>
Pine, Cluster	<i>Pinus pinaster</i>
Pine, Northern	<i>Pinus sylvestris</i>
Plane, Eastern	<i>Platanus orientalis</i>

Plum	<i>Prunus domestica</i>
Rowan	<i>Pyrus aucuparia</i>
Service	<i>Pyrus tomentalis</i>
Spindle	<i>Euonymus europaeus</i>
Spruce	<i>Picea excelsa</i>
Sycamore	<i>Acer pseudo-platanus</i>
Terebinth	<i>Pistachia terebinthus</i>
Walnut	<i>Juglans regia</i>
Willow, Crack	<i>Salix fragilis</i>
Willow, White	<i>Salix alba</i>
Willow, Yellow	<i>Salix vitellina</i>
Zelkova	<i>Zelkova crenata</i>

Even a cursory glance at this list will show that the heavy, hard woods, the Teaks and Ebonies for example, are natives of warm climates. Even woods of the same kind vary in quality according to the situation in which they grow. This is well exemplified in the case of the Northern Pine (*Pinus sylvestris*) growing in Britain. Timber from the Scottish forests is almost invariably of superior quality to the English-grown product. The Scottish wood is harder, closer grained in almost every case.

CHAPTER III

INSECT PESTS OF TIMBER

INSECT pests of timber may be divided into two classes: (1) those which damage the living tree; (2) those which damage the timber after felling. Members of the former class more immediately concern the forester; nevertheless, they cannot be, or ought not to be, ignored by the timber merchant. This division of injurious timber-loving insects is an artificial and not a scientific one.

INSECTS WHICH DAMAGE LIVING TREES. Before we consider any of these insects in detail, we may well give a moment to the enumeration of various methods in which damage is occasioned. A host of insect pests feed upon the leaves of forest trees. In moderation, this habit may do little or no harm; carried to excess, even to the complete defoliation of the trees, over a large area of forest, an event by no means uncommon, the damage becomes serious and sometimes irreparable. The leaves are the food factories of the tree; they are the most

important organs of every tree ; without them nourishment cannot take place, growth is arrested and the tree may be seriously injured or even killed. The gardener is alive to the necessity of conserving the leaves of his charges, the forester is frequently careless of their welfare till too late.

Another and less frequent source of leaf damage is caused by Aphides, of which the common green fly is an example. The Aphides are all provided with a rostrum or beak, in short an awl-shaped sucking mouth which they plunge deep into the plant tissue and through which they suck up the plant juices. Nutriment which should properly go to the upbuilding of the tree is diverted by the Aphides to their own use, with results similar to those caused by the leaf-eating insects.

Conifers are liable to attack by insects which bore into the extreme tips of the stems. At best this form of insect attack causes the end of the tree to bend over or become distorted. As the chief merit of many of these trees is their erect growth, it is evident that a visitation by these insects is productive of considerable damage.

Another group of insects are known as Girdlers from their habit of removing a ring of bark from the tree which they may favour with their

attentions. Needless to add, such a proceeding causes the death of the tree above the ring.

The number of wood-loving insects is legion. Some bore only into the bark and, in themselves, do little harm, but they open up channels favourable for fungal attacks; others tunnel in all directions beneath the bark, and their excavations are often so widespread as to cause the bark to leave the tree, with unfortunate results; others, again, actually bore into the wood, some into the pith of the branches, causing the death of these members, others into the stems of the trees, thus damaging the wood for commercial purposes. In the United States alone the annual loss caused by insects to forest trees is estimated at one hundred million dollars.

To enumerate the British insects which are known to be injurious to forest trees would occupy more space than we can devote to the subject. There are, for instance, more than fifty common insect pests of the Oak in this country; the enemies of the Northern Pine are nearly as numerous, whilst those of the Ash, Elm, Beech, Hawthorn, Poplar, Spruce and Larch are many. A brief consideration of some of the worst offenders, arranged in their orders, must suffice.

LEAF-EATING INSECT PESTS. Order Coleoptera.
A destructive and common forestry pest is the

Cockchafer beetle, *Melolontha vulgaris*. It is doubly obnoxious because, unlike many insect pests, it is dangerous in the larval and adult forms. There are few broad-leaved trees which it will not attack, though it appears partial to Beech, Oak, Sycamore and Elm. The larvæ feed on the roots of seedling trees and nursery stock, the adults upon the leaves of older trees. Briefly the life history of this beetle is as follows: the female lays her eggs, to the number of nearly fifty, six inches or so below the ground and near the roots of some convenient sapling. In about six weeks the larvæ hatch and at once commence to feed upon the roots near by, selecting their feeding points at or near the tender growing tips.

For from three to four years the larvæ continue to feed underground, doing incalculable damage the while. When fully fed they descend lower into the soil in the autumn, make for themselves earthen cocoons and emerge as perfect insects in the spring, ready to carry destruction to the young leaves just as they unfold.

In Scotland and the North of England, the closely related June Bug, *Melolontha hippocastani*, is the commoner insect. It has earned its scientific name from its supposed destructiveness to the Horse Chestnut. As a matter of fact it will attack practically any tree and is especially

partial to Northern Pines, particularly young ones.

Of the leaf beetles (*Chrysomelidæ*) there are many very destructive species. The Poplar leaf beetle is one of the best known in this country, and, as its name implies, is partial to young Poplars; it also attacks Aspens and Goat Willows. In May the female lays clusters of cream-coloured eggs, in batches of a dozen or so, on the undersides of the leaves of the food plant. In about a month the larvæ emerge and feed voraciously on the leaves. Later they pupate on the leaves, from which they hang suspended. Towards the end of summer the adult beetles appear and spend the winter hibernating beneath dead leaves, etc., ready to carry on their work of destruction in the following spring. Like the Cockchafer and the June Bug these beetles are injurious in the larval and adult stages.

Another leaf beetle with a very similar life history is the Willow beetle, *Phyllodecta vitellinæ*, which is particularly destructive to Osiers. The adults destroy the growing points of the young roots, a pernicious habit which results in the tree sending out a number of small branches instead of continuing to produce a single long rod.

The Weevils (*Curculionidæ*) are, in the main, a destructive order of beetles, and not the least

harmful is the Beech leaf miner, *Orchestes fagi*, a pest of the Common Beech. The damage done by this insect "gives the tree the appearance of having suffered severely from late spring frosts. In fact, even practical men often erroneously attribute the injuries to frost." The female lays her eggs in the midrib of a Beech leaf, at about its centre, and in less than a fortnight the larvæ hatch and at once eat their way to the margin of the leaf, following the direction of a side vein. Then the larvæ continue to feed on the substance of the leaf, between the upper and lower skins, which they leave intact, thereby causing a large blister. In less than three weeks they are fully fed and pupate within the leaf tissues. In another fortnight the adults appear and continue the evil work of their immature days by eating countless holes in the leaves. Winter is passed in a state of hibernation in the adult stage.

Of the leaf-eating *Hymenoptera*, by far the most destructive are the Sawflies, of which the Pine Sawfly, *Lophyrus pini*, may serve as an example. This insect, in its larval stage, is very destructive to Northern Pines. In the spring the females lay their eggs in the young Pine leaves. Each female is armed with a sawlike organ, with which she cuts a hole in the leaf and deposits her egg therein. In a fortnight or

so, the yellow-green larvæ emerge. Superficially they closely resemble the caterpillars of Butterflies and Moths; a closer examination will show that these larvæ have more than five pairs of fleshy legs, whereas those of the Butterflies and Moths never have more than five pairs; again Sawfly larvæ have but one pair of eyes, Butterfly and Moth larvæ have more.

There are two broods in a season; the larvæ of the first brood feed upon the leaves of the previous year's growth, those of the second brood feed upon the present year's leaves. Pupation takes place in a little, brown, hard, horny cocoon on the Pine leaf. The larvæ of nearly all Sawflies are gregarious, they live in close association and, as a consequence, they rapidly defoliate the shoots which they favour with their attentions.

A Sawfly which is worthy of mention, on account of the unusual nature of its damage, is *Megastigmus spermotrophos*—it does not appear to boast of a popular name. The female deposits her eggs in the seeds of the Oregon Pine, a Conifer with a very open cone, and therefore its seeds are easily reached by the female Sawfly. The grubs, which somewhat resemble Weevil grubs, irreparably damage the seeds of this valuable timber tree. The closely related *Megastigmus pectinata* causes similar damage to the Silver Fir.

Many of the *Lepidoptera* (Butterflies and Moths) are very destructive to timber trees. Of this order, the larvæ alone are injurious, the adults cannot do any injury even if they would.

The Common Vapourer Moth, *Orgyia antiqua*, is a notorious pest because it will damage any and every tree ; it is not partial to any species. The larvæ are beautifully marked ; red, grey, black, yellow and brown are the predominating colours. From the black head arise a pair of long bristles having the appearance of horns ; on the back there are four bright yellow tufts ; the brown body is spotted with brilliant red. The female, a wingless creature of a grey colour, lays her eggs upon the leaves or young shoots of some favoured tree and the larvæ, being voracious feeders, soon carry out the work of defoliation. The winged male is of a chestnut-brown colour, with a white, crescent-shaped dot on each fore wing. This moth may frequently be met with in London parks ; it would be a really dangerous pest were it not kept in check by parasites.

The larvæ of the Buff-tip Moth, *Pygaera bucephala*, are especially injurious to Oaks and Elms. The female moth lays her eggs in clusters on the undersides of the leaves. When the larvæ first hatch they are gregarious, feeding in groups, hence it is only certain branches of the tree

which are damaged at this stage. Later in life they spread over the tree and cause more widespread damage.

The Winter Moth, *Cheimotobia brumata*, and the Mottled Umber Moth, *Hybernaria defoliaria*, are both highly injurious to forest trees. The former is known as the Winter Moth, because the adults appear about November. The almost wingless females deposit their eggs upon the leaves of many species of trees, but especially Lime, Sycamore, Wych Elm and various fruit trees. The Mottled Umber Moth appears rather earlier in the year, about October, and the wingless female oviposits upon the foliage of Sycamore, Oak, Hazel and Hornbeam principally. The destructive habits of the larvæ have earned the moth the scientific name *defoliaria*.

There is a large family of small moths known as *Tortricidæ* or leaf rollers ; they not only feed upon the foliage of various trees, but they roll the leaves or cripple the young shoots of the plants upon which they live. Of these moths, one of the most notorious is the Green Tortrix, a particular pest of the Oak, though not averse to Ash, Mountain Ash, Hazel, Lime, Beech and Maple. The eggs do not hatch during the same year as they are laid. The adults appear about June, and shortly afterwards the females deposit their eggs on the tree which seems to them the

most suitable. In the following spring, with the budding leaves, the larvæ emerge and at once they begin to roll the leaves on which they are about to feed. Within the rolled leaves they can and do live and feed, protected in this manner from all harm.

The Pine Shoot Tortrix Moth is very destructive to Northern and Austrian Pines in certain parts of the country. During the summer the females deposit their eggs on the tips of the Pine shoots. The larvæ emerge in early autumn and at once proceed to attack the shoots, thereby causing a flow of resin, within which they hibernate for the winter. In the spring, the larvæ attack the leading bud causing it either to die or to become hopelessly distorted, much to the detriment of the growth of the tree.

SUCKING PESTS OF FOREST TREES. Order Rhynchota. Amongst the *Rhynchota* or beaked insects, we find an enormous number of insects which are harmful to plant life and a goodly host injurious to forest trees. The majority of these pests belong either to the *Coccidæ* (Scale insects) or to the *Aphididæ* (Green flies). Practically every scale insect is injurious to vegetation, and as the class is a large one we will mention but a few typical examples.

Of all the Scale insects none is better known

than the Mussel Scale, *Lepidosaphes ulmi*. so called because the insect strongly resembles a miniature mussel. On Mountain Ash, Hawthorn. Apple, Plum, and Pear this scale is most plentiful. Crowded closely on the bark, the female scales may easily be observed with a pocket lens. Towards late summer the females, which are hidden and protected by their mussel-shaped scales, deposit their minute white eggs. During the whole of the winter they remain beneath the parent scale to hatch in late spring. The larvæ are active, six-legged creatures, which wander over the bark of the tree seeking a spot where they may spend the remainder of their lives. After a series of larval moults they settle down, dig their sharp-pointed beaks, which form at once anchor and feeding tube, deep into the plant tissues and suck nourishment therefrom. They have now become stationary and they rapidly secrete a scale as a protection against the elements and their enemies. The males of this species are very rare.

The Willow Scale, *Chionaspis salicis*, is very similar in habits and life history to the Mussel Scale. It is a common insect and mainly attacks Willows and Ash. An even commoner insect is the Brown Scale, *Lecanium capreæ*, a pest of Willow, Alder, Elm, Oak, Sycamore, Apple, Lime, Horse Chestnut and Hawthorn.

The Felted Beech Coccus, *Cryptococcus fagi*, is one of the most destructive of all the British scale insects. The colonies of the insects appear like a white felt on the bark of the tree upon which they live and at times they are as much as half an inch in thickness, causing the eventual peeling away of the bark and the death of the tree. The Common Beech is the favoured food plant of this scale and, curiously enough, the Copper Beech is rarely attacked. The females do not secrete a scale as do the female Mussel Scales, nor do they transform their own bodies into scales after the manner of the Brown Scale, but they secrete a waxy, white cotton wool-like substance, which forms a protection against rain. Beneath the waxy wool, the female lives and deposits her relatively large, pale yellow eggs in the summer. They hatch in the following spring and quickly develop into adult females.

Of the *Aphididæ*, the most destructive to timber trees belong to the genus *Chermes*. Of the six common British species, *Chermes abietis* and *C. strobilobius*, form galls on the terminal shoots of Spruce. *Chermes piceæ* forms a white woolly growth on the leaves and stems of the Silver Fir; *C. pini* forms a similar growth on leaves and stems of Northern and Austrian Pines; *C. corticalis* attacks Weymouth Pines

in the same manner and *C. laricis* whitens the young Larch stems with its woolly growth.

The Larch Chermes, *C. laricis*, may serve as our example. In early spring the females, which have hibernated through the winter, begin to stir themselves; they are known as Queen Mothers. As the whorls of larch leaves begin to develop, the Queen Mothers betake themselves thereto and deposit their eggs in the bases of the leaf clusters. From the pale green eggs, very minute larvæ emerge and spread over the tree, ruining the growth of the leaves or even defoliating the tree entirely. As the season advances the larvæ develop into adult females, secrete the white waxy secretion typical of Chermes, and in its shelter deposit quantities of minute eggs.

Of these forestry pests Gillanders remarks, "*Chermes laricis* may often be found very injurious to young Larches of from ten to fifteen years of age, more especially on those trees growing in hollows or in damp spots; *Chermes abietis* on Spruce trees which are not growing in suitable places, and often on young Spruce trees in the nursery lines; *Chermes piceæ* is often found on young Silver Firs in the nursery. *C. strobilobius* is perhaps more destructive to young trees in the wood, especially those too much overshadowed and not thriving well."

The Girdlers are not numerous in this country. A rare species is mentioned by Theobald and is known as the Beech Agrilus, *Agrilus viridis*; apparently it only occurs in the South of England and is destructive not only to sapling Beeches, but to Oaks, Aspens, Alders and Birches. Damage is done by the larvæ which tunnel beneath the bark and, at times, girdle the tree, though they can hardly be termed true girdlers, as are some of the other insects we shall mention. "As a rule the bark over the larval tunnel splits and leaves behind a ragged crack, which is very characteristic of the damage done by this beetle."

According to Theobald, the adults, which are metallic green in colour, appear in June or July and fly in bright sunshine. The eggs are placed on the bark of the saplings near the ground, usually singly, and exposed to the sun. The larvæ appear in August; they are white and legless, with broad first segment, usually somewhat flattened. They live in the trees for two or three winters, and pupate in April and May in the bark or sapwood, the cocoons being made of fragments of wood. The beetles emerge through holes which are oval below, straight above."

In America, the closely related *Agrilus politus* girdles small branches of Oak trees, whilst

another still more destructive beetle, *Elaphidion villosum*, not only girdles but actually prunes the young twigs of these trees, pupation taking place in the pruned portions of the twigs.

The wood borers are by far the most numerous of the forest pests and, to the timber merchant, they are the most important, for they directly lower the market value of timber.

The world over, Longicorn beetles, so called on account of the extraordinary development of their antennæ, are enemies of forest trees. As in the case of the Girdlers, the larvæ alone are destructive. In Britain there are several destructive species; the Musk beetle, *Aromia moschata*, attacks Willows and Limes; the Large Poplar Longicorn, *Saperda carcharias*, damages Willows and Poplars; the Small Poplar Longicorn, *Saperda populnea*, is injurious to the same trees. Many of these beetles are transported from one part of the world to another in felled and also in living trees. Only recently while examining a collection of beetles from South Africa we were surprised to meet with a species which had previously only been recorded from Australia. Further investigation revealed the fact that a number of New South Wales gum trees had recently been imported into the district and with them certainly the wood-boring beetles.

The Pine Weevil, *Hyllobius abietis*, though not strictly a wood-boring beetle, is one of the worst of our native forestry pests. Contrary to the general rule, it is the adults of this species and not the larvæ which are injurious, and, as may be guessed from its specific name, the Weevil is a pest of coniferous trees. The nature of the attack consists in eating away the bark and cambium of the young shoots, so that they appear to have suffered damage from some rodent. To the young trees when newly planted these injuries are often fatal, older trees are often able to survive an attack. The adults, which hibernate throughout the winter, deposit their eggs in the spring on the roots of trees which have been felled for some years. The larvæ feed on dead wood till the following spring or early summer and change, after a period of pupation, into perfect beetles in late summer.

The closely related species, *Pissodes pini* and *Pissodes notatus*, are both injurious to Northern Pines; yet another Weevil, *Cryptorrhynchus lapathi*, is very injurious both in the larval and adult stages to Alders, Birches, Willows and Poplars. The adults are on the wing in the spring after their winter hibernation; in about a fortnight after egg laying the larvæ appear, and, penetrating the bark, bore right to the pith of the trees they attack; the beetles eat the

bark and sapwood of the younger parts of the trees.

There are two families of beetles, whose members are all injurious to forest trees or to timber. The Bark Beetles or *Scolytidæ* are common in this country, whilst the other family, the *Bostrychidæ*, are almost strangers to Britain and will be mentioned later. Fortunately, many of the bark beetles only attack dead or sickly trees, but there are important exceptions. From a practical point of view these insects fall naturally into three groups, according to the damage they cause to trees. Some of them bore directly into the wood, others damage the surface of the wood just below the bark, others again only penetrate into the bark. As so often happens in the insect world, certain species confine their attentions to definite species of trees; thus *Cryphalus abietis* only attacks Spruce; *C. piceæ* is partial to Silver Fir; *C. fagi* is a pest of Beech and *C. tiliæ* frequents Lime. The various parts of the tree itself also harbour different species, and therefore several species may be found on one tree. Take, for example, a comparatively young Northern Pine. In the top twigs we may have *Pityogenes bidentatus*, and in the smaller branches *Hylastes palliatus*. The stem may harbour *Hylurgus piniperda* and the root surface *Hylastes ater*.

The galleries formed by these beetles in their tunnelling operations are as characteristic of the insects as is their own structure. We can only deal briefly with this numerous family.

The Elm Bark Beetle, *Scolytus destructor*, is one of the worst pests of a notorious family. It attacks Elms with such good purpose as to cause whole sheets of bark to separate from the trees. The closely related *Scolytus pruni* also attacks Elms, but more frequently Apple, Pear and Plum, also occasionally Hawthorn and Mountain Ash. *Scolytus intricatus* attacks Oaks and is more common on the Continent than in this country, and it is recorded that 50,000 Oaks were killed by this species in Germany.

The Black Pine Bast Beetle, *Hylastes ater*, and its relative, *H. palliatus*, are injurious to Northern Pines.

Of the British members of the genus, *Hylesinus*, three species, *H. crenatus*, *H. fraxini* and *H. oleiperda* damage Ash, whilst *H. vittatus* is a pest of Elm.

Scolytids of the genus *Trypodendron* bore into the timber and do not confine their attentions to the bark or the subadjacent wood.

T. lineatum attacks Spruce and Northern Pine; *T. domesticum* riddles the timber of Oak, Birch and Beech with its borings. *Xyleborus dispar*

is another inveterate tunneller of Oaks and certain fruit trees.

Certain of the *Scolytidæ* have the ingenious but injurious habit of growing moulds in their tunnels with the object of feeding their larvæ. From the standpoint of bionomics these fungus-growing beetles are of exceeding interest; from the point of view of the forester, they are a nuisance and worse, for the fungi often complete the work of destruction started by the borings of the beetles.

There are many *Lepidoptera* which are wood borers in their larval stages. An interesting species is *Dioryctria abietella*, whose larvæ bore into the cones of Spruce and Silver Fir during the late summer. Of all the British *Lepidoptera*, however, the palm for destructiveness must be awarded to the Goat Moth, *Cossus ligniperda*. By preference this insect is a pest of Willows, but it also attacks Elm, Ash, Poplar and Oak. The large, heavy-bodied females are on the wing in early summer and deposit their eggs upon the trunk of some favoured tree. Directly the larvæ emerge, they bore directly through the bark and into the wood of the tree. For three years they continue to feed on the wood, boring the while with their powerful jaws, assisted by a fluid which they give off from their mouths with the object of softening the wood. This

fluid, by the way, has a strong goatly scent and has been the cause of the popular name assigned to this insect. At the end of three years, the larvæ, having seriously damaged the tree, travel to the outside and wander about in search of a suitable spot to pupate. Their cocoons are made of silk mixed with wood chips—soft within and armour plated without.

A closely related moth of very similar habits is the Wood Leopard, *Zeuzera æsculi*; even more catholic in its tasks than the Goat Moth, it attacks various fruit trees, Horse Chestnut, Ash, Willow, Poplar, Elm, Sycamore, Birch and Hawthorn.

The Clearwing Moths are also wood borers in their larval stages. The Hornet Clearwing, *Sesia bembiciformis*, so called because it very closely mimics the Hornet, deposits its eggs on the stems of the Goat Willow, and the larvæ bore the wood energetically during the whole of their lives.

Fortunately for foresters in this country, many of the worst pests of forest trees are tropical or sub-tropical. The tropics teem with insect life, and a fair proportion devote their energies to the leaves or stems of trees.

Of the insects harmful to timber, by far the most notorious are the Termites or White Ants. None of them occurs in Britain. They feed upon

wood, and their jaws are well developed to enable them to do so. Some few attack living trees, but, for the most part, Termites confine their attentions to sleepers, telegraph poles, foundations of houses and the like. So industrious are they that they will reduce a good sized log of wood to a fine powder in a single night. Their depredations are dangerous, in that they often eat away the interior of a piece of wood, leaving but a thin husk without a sign of damage. The first occasion on which such damaged wood is subject to strain, collapse takes place, often with disastrous results. In some parts of the tropics anything and everything wooden is devoured by these voracious creatures. Fortunately a few woods are proof against their attacks, mainly because of a high resin content or, at any rate, the presence of some substance which is distasteful to the insects.

Beetles of the family *Bostrychidæ* are also highly injurious to timber; their borings, together with those of the family *Platypodidæ*, are all too frequently to be found in tropical timbers imported to this country. The wide, wormy tunnels of many of the *Bostrychids*, and the smaller, more numerous borings of the *Platypodids*, not only render the wood unsightly but seriously affect its strength.

The familiar "worm-eaten" wood in this

country, having the appearance of being punctured by innumerable shot holes, is in reality wood which has been damaged by beetles. Most commonly the culprits are either *Xestobium domesticum* and *X. tessellatum*, the Death Watches, or some member of the genus *Lyctus*. It is a strange fact that many timber men, even some of wide experience, are quite unaware of the fact that "wormy" wood (Fig. 83) is the result of beetle attacks. There are many who still assert that worms are the cause, with the result that the real culprits, the beetles, escape attention at their hands.

Of the *Hymenoptera* certain tropical Carpenter Bees of the genus *Xylocopa* do a considerable amount of damage to timber, and the larvæ of the British Wood Wasps, *Siricidæ*, are also wood borers, though to their credit it may be said that they favour decayed timber.

Before passing to the fungoid pests of timber we are constrained to mention a creature which rivals even the White Ants in its damage to wood. We refer to the Shipworm, *Teredo navalis*. A bivalve mollusc, with valves so small that they may easily be overlooked, the adult Shipworm is from six to twelve inches long. It is a marine creature and causes much havoc amongst piles, ships' bottoms and all woodwork exposed

138 TIMBERS AND THEIR USES

to sea water. The creature carries out its boring of long, parallel galleries by the aid of its powerful sucker-like foot. As with the Termites there are, fortunately, certain woods which are proof against Shipworm attack.

CHAPTER IV

FUNGOID PESTS OF TIMBER

As with the insects, so with fungoid pests of timber, we may divide our subjects into artificial groups. In the case of standing timber there are fungi which are directly injurious to the wood—these form our first division. Other fungi are indirectly injurious, in that they damage leaves, bark, roots, etc., and thereby impair the growth of the wood. The third class of injurious fungi are those which damage felled timber.

For the better understanding of the means by which fungi cause injury to their hosts, as the plants upon which they grow are called, we may well explain briefly their nature and mode of life. All fungi are devoid of chlorophyll or green colouring matter, an eloquent fact to the botanist, for he knows that absence of chlorophyll entails inability to form food material. How then does a fungus live? Either upon dead or decaying matter when it is known as a saprophyte, or upon living material when it is called a parasite.

There is an intermediate class of plants known as partial or semi-parasites of which the Mistletoe is a good example. These semi-parasites steal some of their food from their hosts and, being provided with green chlorophyll laden leaves, elaborate the rest of their food from the air. It is clear that as they contain chlorophyll they are not fungi. We will consider them here, however, for convenience' sake, just as we studied the shipworm along with the insects.

With saprophytes we are not immediately concerned; parasites are the organisms causing disease. When present in small numbers they may do no great harm, but there is always the danger that they may increase rapidly and so set up a condition of disease.

The various forms of fungoid pests cannot be described in a few words. In general it may be said that they are either external or internal, that is they either grow upon the surface of their hosts or actually in their tissues; they are, in short, either ecto or endo-parasites. As a rule the vegetative portion of the fungus consists of a mycelium, that is a threadlike growth forming at times a dense matted structure which either chokes up the tissues of the host in the case of an endo-parasite or ramifies over its surface if it be an ecto-parasite. Reproduction may take place vegetatively (i.e. portions of the

mycelium may break away and grow into a new plant) or by means of spores, which function as the seeds of higher plants, though the two are not analogous.

For the most part fungi are classified according to the structure and arrangement of their spores. They may be borne on basidia, little stalked structures which themselves are situated upon gills as in the edible mushroom, or within pores, as in the case of the bracket fungus (*Polyporus*). Or they may be borne in little sacs, known as asci, and the asci again may be exposed or concealed in cup-shaped cavities known as perithecia. Yet another form of spore is borne in chains upon a small stalk; these chains of spores are known as conidia and, like the asci, they may be exposed or borne in hollows, known as pycnidia. Whatever the nature of the spore, of its formation and growth, it is the reproductive organ upon which the fungus depends for its spread. All spores are very light and are easily blown about by the wind. Whenever a spore falls upon a suitable host it germinates, sending out a tube which in time becomes the mycelium of a fungus. Small wonder then that, owing to their small size and easy transportation, fungus spores form a ready means of distribution for the majority of injurious pests.

A word or two concerning plant physiology may lead to a better understanding of these harmful parasites. In the case of ordinary green plants, the hosts of the parasites with which we are concerned, all food substances, with the exception of carbon, are absorbed through the roots in the form of watery solutions. Carbon is taken up by the leaves in the form of the gaseous compound carbon dioxide. Without proceeding further it is clear that the roots and leaves are most important plant organs. Actual root absorption takes place through the root hairs, very fine threadlike roots with thin walls which occur just behind the growing points of the root branches. From the root hairs the water with its dissolved food passes to the roots proper and enters the water-conducting system which we have described elsewhere. From the finest roots, through the stem, to the extreme leaves this liquid food passes. In the leaves starch and sugar is built up from this liquid food, and from the carbon of the carbon dioxide taken up from the air, at the same time, a great deal of the water which has served its purpose as a vehicle for the transport of the food passes off into the air. A fair-sized tree will give off more than 150 lbs. of water a day. The food manufactured in the leaves passes by other channels to the growing points

of stem and root, and is there used in the formation of new tissue, for a plant cannot grow without food any more than an animal. The carbon dioxide which a green plant takes up is derived from the air, and it enters the plant through minute pores on the leaves called stomata and, to a lesser extent, through pores on the bark called lenticels. On most leaves the stomata are on the lower surface, a wise provision, for in this position they are less likely to become clogged by dirt.

When a plant is attacked by a parasite one or more of several things may happen. The parasite may steal the food which rightly belongs to and is necessary to the well-being of its host. It may, if it be a root parasite, seriously interfere with the absorption of water and dissolved food material or, if it be a leaf parasite, it may hinder the free passage of carbon dioxide. Again, leaf parasites may partially or entirely put a stop to the manufacture of sugar and starch in the leaves. They may so injure the tissues of the plant as to prevent the ascent of raw food material or the descent of elaborated food material. There are other and less obvious results of fungoid attacks, but, in the main, their injury is the result of impairing the functions necessary to the growth of their host.

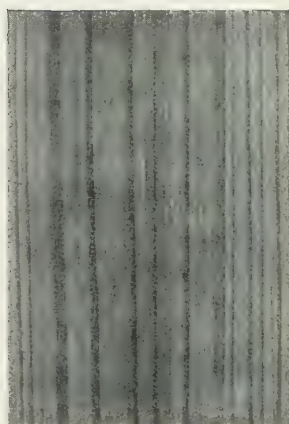
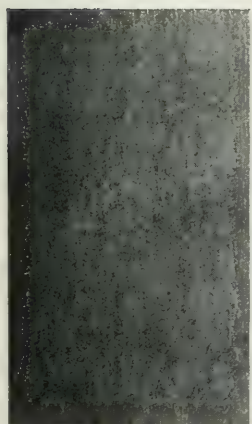
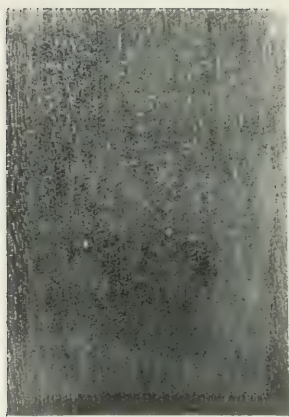
Even the ecto-parasites, such as the mildews,

Erysiphæ, which are common on the leaves of Oak, Beech, Ash and Birch, though their mycelia are situated on the surface of their hosts, require nourishment, and this they obtain by sending down little root-like organs into the tissues over which they spread.

FUNGI CAUSING DIRECT INJURY TO LIVING TREES. Wound fungi. The parasites which we are about to consider are called wound parasites, for the reason that they always gain admittance to the healthy timber through wounds in the bark. Such wounds may be caused in numberless ways: by insect damage; by bad pruning of the branches and accidental injury; by the gnawing of rodents, rabbits and the like, and even by shot-holes in certain cases.

Among the commonest of these wound parasites are the bracket fungi. Several species may be met with in the course of a short ramble, for they abound everywhere. *Polyporus sulphureus* attacks Oak, Poplar, Pear, Hazel, Willow, Larch, Walnut, Chestnut, Alder, Apple, Cherry, Maple and the conifers generally. In America this parasite is known as Red Heart Rot.

Polyporus fulvus attacks conifers, as does *P. borealis*; on Oak we commonly find *P. ignarius* and *P. dryadens*; whilst *P. vaporarius* is now commonly met with on the wood of felled conifers.

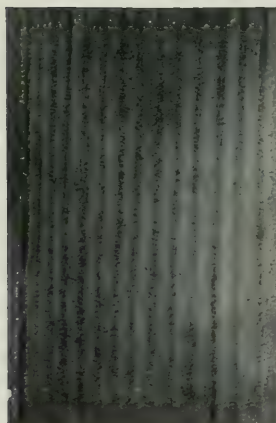
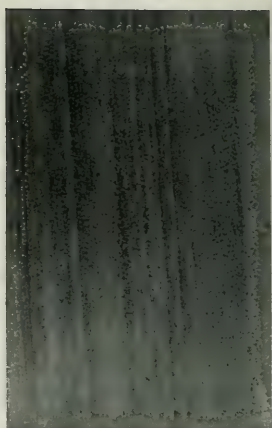
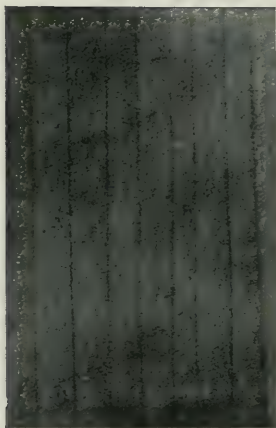


33. HALDU.

35. AUSTRALIAN WILD CHERRY.

34. TURPENTINE TREE.

36. SWAMP CYPRESS.



37. PORT ORFORD CEDAR.

39. COLUMBIAN PINE.

38. BUNYA PINE.

40. CYPRESS PINE.

Polyporus sulphureus, as its name implies, is of a yellow colour, bright yellow below and orange or almost red above. It grows at right angles from the stem of its host in a series of tiers or steps. When young it is soft and cheesy, but with age it becomes harder and woody. The spores are borne in the countless pores with which the lower surfaces of the brackets are perforated. So much for the spore-bearing organs of this destructive parasite. Let us follow the fortunes of one of the spores from the brackets of this fungus. Light as air the spore is carried on the slightest breeze. Should it alight on a tree wound sufficiently severe to have penetrated the bark it will germinate and send out a long fine filament, the first stage of its vegetative growth. This filament branches rapidly and spreads through the tissues of its host, especially in the medullary rays. Decay sets in at once, and the wood soon assumes the appearance of red-brown charcoal, hence its American popular name. Later, the decayed portions crack, and within the cracks may be found the dense felt-like mycelium of the causative fungus. "The ultimate filaments of the fungus penetrate the walls of all the cells and vessels, dissolve and destroy the starch in the medullary rays and convert the lignified walls of the wood elements back again into

cellulose. This evidently occurs by some solvent action, and is due to a ferment excreted from the fungus filaments, and the destroyed timber becomes reduced to a brown mass of powder."

Polyporus ignarius, in fact all the species of *Polyporus* have very similar life histories. The mycelium of *P. ignarius* penetrates the medullary rays of its host and destroys the starch which is always stored there. *P. dryadens* attacks its host in a similar manner. "It occasionally happens that an Oak is attacked by both these fungi, and their mycelia become intermingled in the timber; when this is the case *the starch grains remain intact in those cells which are invaded simultaneously by the hyphæ of both fungi.*"

P. dryadens and *P. fulvus* both destroy the middle lamellæ of their hosts, with the result that the tracheids are isolated.

The Yellow Toadstool, *Agaricus melleus*, is another common external parasite of our forest trees. It is found most commonly on Conifers, Beeches and Oaks; growing invariably at the base of its host it has the appearance of a brownish yellow mushroom; its mycelium is shiny black and grows in dense masses around and within the tree roots. The black hyphæ pass from the roots up into the stem and rot sets in.

A diseased tree may easily be recognized by

its hollow sound when tapped. The disease spreads by means of the long black hyphæ and not by means of spores as in *Polyporus*.

A wound parasite actually introduced into the wound is the cause of Bluing in Pines. The spores of the fungus, *Ceratostomella pilifera*, are introduced into the base of the tree by a boring beetle. The mycelium spreads upwards through the sapwood of the whole tree causing it to turn a characteristic blue colour. Blue wood is as strong as normal green wood, is tougher, and when dry it will last as long; but when wet it rots rapidly.

The last-mentioned fungus confines itself to the sapwood of its host, the Heart Rot, *Trametes pini*, on the contrary, attacks the heartwood only. The spore-bearing organs are brackets, very similar to those of *Polyporus*, brown beneath and black on the upper surface. An enemy of Conifers, this fungus, in its early stages, produces a number of small holes in the wood. Later, the holes are arranged to correspond with the annual rings and increase in number so that the result is the formation of a number of cavities, separated by their plates. The wood first changes to a pale grey colour and afterwards becomes red-brown reticulated with black.

A closely related parasite, *Trametes radiciperda*,

is also an enemy of Conifers. This fungus is very similar to the *Polyporus*, but its spore-bearing organs, instead of taking the form of aerial brackets, are subterranean plates attached to the roots of the host. A tree attacked by *T. radiciperda* is easily recognized by its pale yellow leaves which soon fall and by the death of the lower part of the stem, though higher up it appears quite normal. The mycelium travels up the tree in the cambium of its host, sending branches in all directions into the wood and rapidly reducing it to a rotting mass. From time to time the mycelium breaks out from the bark and forms the spore-bearing organs, yellowish white plates, perforated by innumerable minute pores in which the spores are found.

The diseased wood presents a very characteristic appearance. Of a yellowish brown colour, it is spotted here and there with oval white patches, to each one of which there is a black centre.

One of the worst of all parasites of living trees is the so-called Larch disease or Larch canker, *Peziza Willkommii*. The causative fungus produces dead, sunken patches on the bark of its host. Below these patches, no wood growth takes place. From the surface of the sunken areas the spore-bearing organs arise; they are small egg-cup-shaped structures, greyish without

and bright orange-yellow within. As the disease advances, the areas of the sunken patches become decayed and resin flows freely therefrom. Eventually the whole branch or even the tree is killed by its parasite.

We may here conveniently mention a partial parasite which must not be confused with the fungi we have mentioned or are about to mention. Mistletoe, *Phoradendron flavescens*, is a flowering plant possessing green leaves, capable of taking up carbon dioxide from the air and, as such, in no way related to the lowly fungi. Mistletoe attacks a variety of trees. It is propagated by seeds, which are carried by birds from host to host. When the seeds germinate they send down attaching organs called haustoria into the tissues of their host. The haustoria enable the Mistletoe to tap the raw food material and convert it to its own use. The result is that the ends of the branches upon which Mistletoe grows are rapidly killed through lack of nourishment.

Of the parasites which cause indirect injury to timber we can only mention a very small percentage. The leaf-infesting fungi are an enormous host, but the damage they cause is similar in every case, they prevent the leaves from building up food material. To the man who is interested in timber these leaf-infesting

fungi have a greater importance; when the leaves of any tree are damaged the wood produced during the year is small in quantity and poor in quality.

Among the commonest leaf parasites are the Mildews, *Erysiphæ*, which usually take the form of an ash-grey growth on the leaf surface. Oaks, Beeches and Birches are frequently attacked by mildew, but any tree is liable to the fungus. A strong, healthy tree in a normal season may be but little damaged by mildew, but in a damp summer or if the host plant be weakly the injury caused by these fungi may be considerable.

Some leaves, especially those of Sycamore and Maple, are liable to attack by the Tar Spot fungus, *Rhytisma*, so called on account of the shining black patches of fungus growth which appear on the leaves. The vegetative stage of the parasite only is reached while the leaves are living on the tree; after leaf fall the spores are formed.

The Rusts, *Uredinæ*, are the most injurious of all the leaf fungi. They are so called because they produce rust-coloured spots upon the plants they infest. Their life histories are often complicated and the reader who would go further into the matter is urged to refer to some of the recognized textbooks on the subject. Two hosts

are an essential to the completion of the life histories of most of the Rusts. For example the rust of Ash, *Puccinia fraxini*, winters on Marsh grass; the Pine-blister, *Peridermium pini*, completes its life cycle on the Groundsel; the Spruce fir rust, *Aecidium abietinum*, has the Rhododendron as one of its hosts; the rust of *Pinus strobus* is parasitic also upon Currant bushes, and the same fungus attacks Junipers and Hawthorn.

There are some fungi which attack converted timber. *Polyporus vaporarius*, though a wound parasite, will, under favourable circumstances, attack stacked timber. Of all the timber diseases by far the most injurious is "dry rot," *Merulius lacrymans*. The conditions most favourable to the germination of dry rot spores are bad ventilation, warmth, moisture and an alkaline medium on which to grow. When badly attacked by this fungus the wood is riddled by the fungus hyphæ and its surface is coated with a grey felt of mycelium. This vegetative growth may spread over intervening spaces to other timber. The effects of dry rot are most disastrous to infected timber. The hyphæ penetrate to the pith rays, for there some of the cells retain their protoplasm from which the fungus obtains its nitrogenous food. From the walls of the wood vessels carbon and mineral matter are obtained. Infected wood rapidly becomes lighter in weight,

cracks and warps. Later a dry stage, the dry rot stage is reached when the wood crumbles up into a fine brown-coloured powder, and should moisture be present the whole turns into a soft cheese-like mass. Properly seasoned timber which is kept reasonably dry is little liable to attack by dry rot, in fact the fungus cannot grow in dry air. This disease is doubly to be feared because it may spread either by means of its mycelium or by its spores. The latter may be carried from diseased to healthy timber in a number of different ways. The spores are small and light and they are easily carried on air currents; insects and rodents may transport them about their bodies, they may even be carried on woodworking tools or on the hands and clothes of workmen.

Of the other enemies of timber we have no space to speak, some of them, such as the Coral spot disease, frequently so conspicuous on pea sticks in the shape of bright red pustules, only attack dead and decaying wood. In any investigation of fungoid growth on wood it is essential to discern as a preliminary whether the presence of the fungus is due to the decay of the wood or whether the decay is due to the presence of the fungus. A distinction with a difference and an important difference.

CHAPTER V

ACCIDENTS DURING GROWTH

FROM various causes, unsuitable soil, unusual or rapid climatic changes, etc., checks may take place in the growth of standing timber, to its detriment as a commercial commodity. Old age, with its concomitant decay, which usually begins at the centre of the tree, can hardly be termed an accident during growth, yet it is an event which cannot be left out of our reckoning. Let us therefore pay some attention to decay.

The condition of a wood may often be determined more or less accurately by its external appearance. Wood of good quality usually has a bright healthy appearance which is foreign to the duller inferior quality wood. This rough inspection test is difficult to reduce to words, but the timber expert will realize what we mean. Decay in its incipient stages is most readily determined by colour. Wherever a serious wound, whether accidental or purposeful, has occurred to the bark of a tree it is likely to lead to decay. Air and moisture enter the wood

and fermentation takes place with the consequent destruction of the lignified cell walls. The careful forester, when he finds it necessary to cut away part of a tree, covers the wound with a preservative so that decay may be prevented till such time as the natural growth of the tree covers the spot with a new layer of bark. When wounds are left untended decay gradually spreads down the centre of the stem and thence outwards with the result that the centre of the tree rapidly becomes hollow. It is always wise to carefully examine the wood below an old wound to discover the extent of decay, for an exterior inspection will not reveal the fact. In certain cases, and for a limited number of purposes, partially decayed wood is in request, but, speaking generally, all timber which is "foxy" or shows any signs of decay is materially reduced in value.

Another defect, and fortunately only a local one, may arise from injury to the bark. As we have already explained, in the event of injury the tree forms new layers of tissue to cover the wound. Should the injury not be deep seated little harm may result beyond a slight scar on the bark. If, however, the damage extend to the cambium, the tissue from which new wood is formed, although healing growth may take place, the new wood may fail to adhere

to the wood formed prior to the injury. Such a defect is not easily detected in standing timber, but when cut the wood below the site of the injury peels away in flakes.

Shakes, of which there are three kinds, are all too common defects in timber. A shake in plain terms is a split or cleft in the timber; it may be a heart shake, star shake or ring shake. Of these, the most frequently met with is the heart shake. A heart shake is a split which passes right across the centre of the stem and is wider at the middle point than at its extremities. Shakes of this nature may occur in practically all trees. Laslett, in his *Timbers and Timber Trees*, states that certain kinds of Northern Pine, Pitch Pine, Greenheart, True Teak and Tooart are especially liable to heart shakes. Whilst other Northern Pines, Canadian Red Pine, Elm, African Oak, Spanish Mahogany and Sabicu are little liable to this defect. As Boulger states, "One of the worst forms of this defect is when, owing to spiral growth, the shake shifts its direction as we trace it up the stem. It may in this way sometimes be nearly at right angles at one end of the tree to its direction at the other, thus rendering the conversion of a log into plank wellnigh impossible.

It is this hindrance to the conversion of timber into plank that constitutes the main

practical importance of all forms of shake, as they do not at first involve any decay, and consequently do not much interfere with the employment of the logs in bulk. Heart shake, however, is probably in itself an indication of that incipient decay that comes when timber has passed its maturity and the older layers shrink more than the outer."

Star shakes (Fig. 81), as their name implies, are splits which radiate from the centre of the tree outwards, so as to form a star. Sometimes they extend but a short distance from the centre, again they may extend right across the tree.

Ring shakes arise when the annual rings of the wood fail to adhere to one another, with the result that circular fissures, parallel to the bark, occur in the wood. It is probable that all cases of ring shake are due to external causes, and various theories have been propounded to account for them. The complete defoliation of the tree by insects may cause such a check to growth that ring shakes are induced. Sudden and severe frosts are said to account for the defect, and in the tropics the intense heat may be the cause. Another theory is that the swaying of the stems in all directions in the wind induces ring shakes.

Whatever form a shake may take it is likely to affect the conversion into plank very seriously,

especially as all shakes become more pronounced during drying, owing to the fact that the outer parts of the wood dry more rapidly than the inner. In certain cases, especially in heart shake, the defect may be so pronounced that it may be detected by an examination of the bark before the tree is felled.

Certain coniferous timbers are very subject to Resin or Pitch Pockets (Fig. 77). These pockets are merely accumulations of resin of such an extent as to form cavities of various sizes. As a rule they are more or less linear in shape and, unless of large dimensions, do not materially weaken the timber, though they spoil its appearance. It is impossible to indicate the position of a pitch pocket till it is exposed in working.

One of the commonest timber defects is caused by knots, which produce "local cross grain." A knot is really a portion of a branch which passes through the tissues of the stem. When the branch dies the knot becomes merely "a peg in a hole, and likely to drop out after the tree has been sawed into lumber." Knots of large size or number seriously weaken wood, moreover they render it exceedingly difficult to work. Small knots are not nearly so injurious, in fact they may, in certain cases, strengthen the wood.

The direction of the grain of timber may, on occasion, be the cause of serious defects. Sometimes, instead of the straight-grained timber which is always in request, its direction may be diagonal, either owing to errors in cutting or to the natural growth of the tree. Diagonal grain results in a serious weakening of the timber. Spiral-grained timber or "torse wood" is also to be avoided. It is all too common and results from defects in the growth of the tree.

CHAPTER VI

THE WORLD'S TIMBER RESOURCES

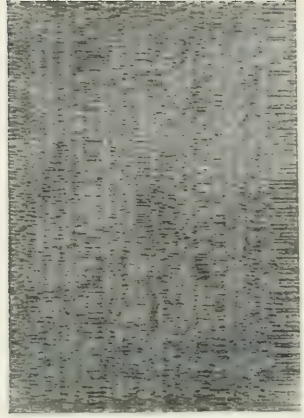
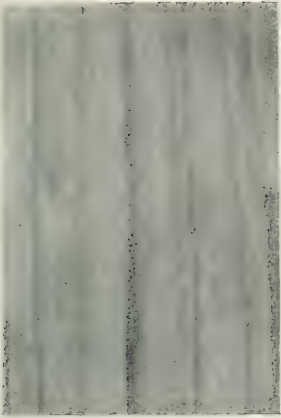
To obtain reliable data of the world's timber resources at the present time is an almost impossible task. We have derived most of our information on the subject from the reports of the Forestry Commission of Victoria, Australia, and we must express our indebtedness to the Agent General of that Colony for the information he has so generously supplied.

Great Britain. Forestry in this country has always been neglected; in the care of her national forests Britain falls far behind many of the continental countries. The area of forest land is approximately 2,695,000 acres, or about four per cent of the whole country, a small percentage compared with France and Germany. "Her (Britain's) climate, however, is mainly determined by her exposed insular situation, the currents of moist air which sweep across the country from the surrounding ocean affording an ample rainfall, extending over the greater

part of the year ; while, as regards the distribution of this rainfall, a large portion of the treeless waste lands is covered with heath and peat mosses, which absorb enormous quantities of water and yield it again in the form of springs and streams, as well as in evaporation."

England, from the earliest times, has possessed the most valuable forests. "In addition to Elm, Beech and Ash, the country was covered with large tracts of Oak, which, with its successive growths through long ages, furnished timber of the finest quality for shipbuilding and general construction." In the South of Scotland there were considerable forests of Oak and Elm and the highlands are rich in Red Pine. Ireland was famous for her Oaks which, during the Plantagenet regime, were exported to England for shipbuilding and church building.

"The forest in the early feudal period was regarded primarily as a preserve and shelter for the king's game, and the Norman kings especially were noted for the harshness and cruelty with which they depopulated large tracts of country to secure for themselves extensive hunting grounds. The Conqueror, in forming the New Forest in Hampshire, is said to have razed or swept away twenty-two parish churches and many villages, chapels and manors ; while Domesday Book records that, in carrying out

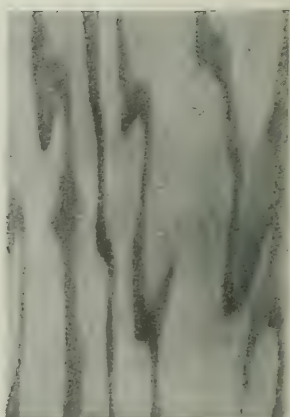
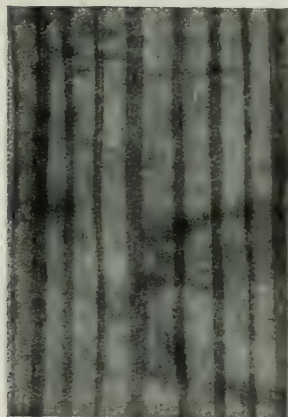
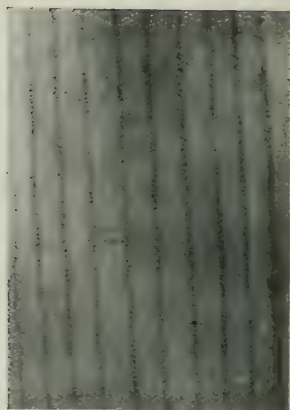
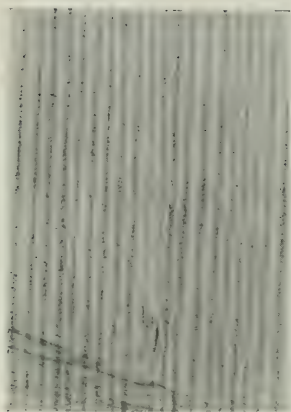


41. HOOP PINE.

43. NORTHERN PINE.

42. KAURI PINE.

44. WEYMOUTH PINE.



45. SILVER SPRUCE.

47. OREGON PINE.

46. VIRGINIA SPRUCE.

48. OREGON PINE.

the work, 108 places, manors, villages and hamlets suffered in greater or less degree. The same ancient register, in showing that there were no fewer than 1,033 woods or forests in the five counties of York, Derby, Kent, Sussex and Surrey, records that the Conqueror had in possession 68 forests, 13 chases and 781 parks."

Henry VIII was an arch enemy to forestry in Britain; he seized the valuable forest lands belonging to the Church, many of them very well managed, and sold them or gave them to his favourites. Elizabeth also reduced the area of Crown forests, selling the timber to pay for the Irish wars, an easier proceeding than asking parliament to vote supplies. Cromwell, also, was no respecter of Crown forests, he is said to have obtained over £10,000,000 from Church lands alone, £1,200,000 from Crown lands and £656,000 from royal forests and manors. Matters had gone so far that in the reign of Queen Anne it was forbidden to alienate Crown lands except by leases for certain fixed periods. The most famous British historical forests are Sherwood Forest in Nottinghamshire, New Forest in Hampshire and the Forest of Dean in Gloucestershire. The first-named was for long regarded as one of the most valuable forests of the Crown. Sherwood, as a forest, may now be said to be non-extant.

The New Forest consists, for the most part, of Oak and Birch, with some Northern Pine and Larch. "The right of pannage in Britain is chiefly exercised in this forest and, in a good mast year, about 5,000 swine are admitted."

The Forest of Dean comprises Oak, Beech and Northern Pine, with some Chestnut, Walnut and Larch. This forest has long been noted for the excellence of its Oak. "In the last century large drafts were made on it for the Navy, and at the present day supplies are still obtained from it for the dockyards and for other public works. The forest is burdened with certain privileges granted long ago to 'free miners,' who have the right to dig on it for coal and iron, and in certain cases to obtain fuel and mine timber."

"Among the smaller and less important forests and plantations are Bere, Alice Holt and Woolmer in Hampshire, Parkhurst Woods in the Isle of Wight and Delamere, Salcey, Hazleborough and Chopwell. None of these exceed 3,000 acres in extent, and most of them have something like 1,000 acres under tree cover."

Of the more important private woods in Britain may be mentioned those of the Mansfield estate near Scone, about 8,000 acres, and the Athole Larch plantations near Dunkeld, about 10,000 acres. The majority of the private

woods are maintained by a systematic planting of such trees as Northern Pine and Larch. A great deal of capital is sunk, and the output is used mostly for the home market, the class of timber being that required for ordinary carpenters' and joiners' work—Oak, Elm, Ash, Beech, Spruce, Silver Fir and Larch; timber for pit props, such as Northern Pine and Larch; and for railway sleepers, Northern Pine, Spruce and Larch.

Enormous quantities of wood are imported into Britain for various purposes. In ship-building, a number of the smaller vessels, barges and boats are still largely made of the best quality Oak. For the interior fittings and for decks of steamers, Indian Teak and American Pitch Pine are used. Teak is more durable than Oak and it does not cause rust and decay in nails and bolts. Certain Australian hard woods, despite their weight, have been used for frameworks; Jarrah, Ironbark and Blue-gum have proved very strong and durable. For boats, Larch, Northern Pine and Spruce, and for oars, Ash are used. Of the native timbers, Northern Pine and Red Deal are used for masts and rudders, whilst Larch, Red Deal, Kauri, White Pine and Douglas Fir are imported for the same purposes.

For building purposes, the native Spruce,

Silver Fir, Pine and Larch are used, also the imported Pitch Pine, Deals and White Pine. For staircases, Oak, Beech, Ash, and for cheaper work, Pine ; for wainscotting, Oak, Pine and Larch ; for furniture, Oak, Ash, Beech, Elm and Birch and the imported Oak, American Ash, Walnut, Mahogany, Maple, Cherry and Rosewood ; for bridges, etc., Oak, Larch and Northern Pine.

For wheels, naves and hubs are made of Elm, Oak and Ash ; spokes, of Oak and Ash or of American Oak and Hickory ; carriage poles, of Birch, Ash and Oak ; shafts, of Ash, the best being American Ash, and Lancewood ; carriage bodies, of Oak, Ash and Beech, and the panels of Lime and Poplar. In railway carriage work, the frames are made of Oak and Ash ; roof ribs, of Elm, Ash and Northern Pine ; panel work, of Pine, including Pitch Pine, Poplar, Maple, Ash, Mahogany, Teak and Walnut. For the frames of trucks, New South Wales Tallow Wood and Ironbark have been much used. Larch and Northern Pine are used for sleepers, Oak is too valuable for this purpose. As a rule, wood used for such purposes is injected with antiseptics, usually creosote or zinc chloride, to render it more durable. Recently, Jarrah and Ironbark have been used with success ; these woods have a useful life of twenty-five to thirty-five years

in Australia. Paving blocks were formerly made of Beech, Elm and Oak, and, to a larger extent, Deals, Northern Pine and American Pitch Pine. Since 1895, however, West Australian Jarrah and Karri, and, in a less degree, New South Wales Blackbutt have been substituted for these timbers, the shipments from the western colony to London especially being very large.

Though a small producer of timber, Great Britain is one of the largest consumers of forest produce in the world, therefore she depends largely on her imports. A large amount of this imported timber is obtained from the colonies, and the most extensive shipments from foreign countries are from Russia, Scandinavia and the United States. In addition to timber, various forest products such as Cutch, Gambier, Valonia, Myrobalams, Sumach, Hemlock, Bark and Wattle Bark are imported.

The shipments from Canada are mainly White Pine and Spruce, Tamarack, Oak, Elm, Birch, Maple and Basswood. From India, Teak, Padouk, Ebony, Cedar, Sandalwood, Red Sanders and Boxwood. From the Straits Settlements, Gambier, Indiarubber and Gums. From North Borneo, Camphor, Gutta Percha, Indiarubber and Damar Resin; from South Africa, Wattle Bark; from West Africa, Indiarubber and Copal Gum. From Guiana, Greenheart,

Mora ; from Honduras, Mahogany, Logwood and Indiarubber ; from Jamaica, Logwood and other dye woods. From Australia, various hard woods, also Red Cedar, Blackwood, Beech, Silky Oak and Bean ; from New Zealand, Kauri Pine and Kauri Gum. Among the minor imports are Eucalyptus Oil, Red Gum, Kino and other medicinal preparations.

France. France ranks with Germany as one of the great Powers of Europe which for generations, amid far-reaching political changes, has steadily pursued an enlightened national policy in the care and protection of her forests. She may justly lay claim to be the pioneer of modern forestry, and many countries have copied her methods. They have, in fact, been modified to meet the national conditions of countries so diverse in climate configuration and forest resources as British India, Japan and Cape Colony.

In the middle of the sixteenth century Royal intervention was invoked to prevent the reckless waste of valuable timber which had taken place up to that date. Henry IV, assisted by the Duc de Sully, regulated the cutting of forest trees. Louis XIV, at the instigation of his minister Colbert, produced an effective law in the Forest Ordonnance of 1669, which became the model of all subsequent legislation, ending,

in the year 1827, with the present Forest Code. "The principle which underlies the Forest Law of France is that the State not only lays down rules for the protection, care and working of the national and public reserves, and for the forest lands held by communes, corporations and public institutions, but that it also imposes restrictions on the right of private owners to clear or destroy tracts of forest on their lands."

Therefore private owners who wish to clear wooded land on their estates must apply for permission to do so to the Forest Department, at least four months before they propose to carry out the work. Clearing may be forbidden if it be deemed necessary in the public interests to do so, and landowners contravening the laws may be heavily fined in addition to being ordered to replant the cleared area. "The clearing of private lands may be forbidden if the maintenance of tree-growth is deemed necessary for any of the following purposes: To maintain the soil upon mountains or slopes; to protect the soil against erosion and flooding by rivers, streams or torrents; to insure the existence of streams and watercourses; to protect dunes and coasts against the erosion of the sea and the encroachment of moving sands; for the purposes of military defence, or for the public health."

The Minister of Agriculture is also President of the Forest Council, which comprises the Minister, the Director of Forests and three heads of departments. The first controls the bureau for legal matters, forest instruction, records and acquisitions ; the second, the bureau of working plans and utilization ; and the third that for reafforestation of mountain tracts, public works, replanting and clearing. The staff controlled by the Council comprises 36 conservators, the higher controlling and inspecting officers ; 225 inspectors in charge of divisions ; 242 assistant inspectors, who personally direct the work in their cantonments ; and 328 rangers with somewhat similar duties. There are also approximately 3,500 forest guards of various grades.

The training for the higher posts in the French forest service is shorter than in Germany, nevertheless it is highly efficient, the officers usually attaining to a higher level of professional excellence. The forestry school is, in normal times, situated at Nancy, and the course extends over two years. There is also a well-managed school at the Domaine des Barres in Loiret for men of the higher grade of forest guards who have displayed ability in their work, and desire to qualify for admission to the ranks of the superior staff.

Candidates for admission at Nancy must have

had a good general education at a high school and be between the ages of eighteen and twenty-two years. They must pass an entrance examination in mathematics, chemistry, natural philosophy, mechanics, history, geography, plan drawing and German. Instruction is provided free by the State, but a charge of £60 a year is made to cover board as well as the supply of books and instruments. The course comprises forest economy and management, including silviculture, or the methods of working and utilization; forest management in other countries; botany, geology, zoology, applied mathematics, agriculture and German. Military instruction completes the list of subjects, and includes rifle shooting and squad and company drill, with some teaching in artillery works, fortifications and outpost duties.

Recent statistics are hard to obtain, but a few years ago it was estimated that the public forests covered an area of 2,691,000 acres, whilst those of the communes and public institutions covered 4,738,000 acres, or together 7,429,000 acres, representing 5·6 per cent, or one-eighteenth of the total area of France. In addition 16,000,000 acres of forest land are in the hands of private owners.

Of the 87 departments of France, the 27 which are situated on the southern and eastern

frontiers along the Pyrenees and Alps contain 72 per cent of the total area directly controlled by the Forest Department. The forest proprietors may not clear any forest lands without a special permit from the President, while communal forests can never be divided among the inhabitants. Whenever a public body possesses 24·7 acres of forest, one-fourth must be kept in reserve. This wise provision is in case of emergencies or special demands on the funds of the communes, such as damage by fire or flood, or the building of churches or schools.

These same public reserves are tended by guards selected with the approval of the forest service, and the sale of timber and other produce is made under its direction. "In fact, all the operations of conservation and management are carried out by it in return for a fixed tax. The bulk of these forests are worked upon the plan known as 'Coppice under standards,' the basis of which is the cutting of the shoots or sprouts which spring from the stumps of trees at intervals of from 15 to 45 years. To secure a fairly uniform annual return, the whole forest if it be of small area, or each of its management units, if it be a large one, is divided into as many compartments of equal productive power as there are years in the rotation fixed for the coppices, and one of these compartments

or blocks is cut over annually. At each cutting a certain proportion of the most vigorous seedlings or shoots is left to grow for several rotations. These are the standard or seed trees which promote natural regeneration from their seed, and also produce mature timber when required, as distinguished from pit props and firewood. The percentage of the reserves in question which are thus worked is 53, while that of high or timber forest is only 31, and simple coppice 14. It is the plan of management which yields the highest return on the capital invested, as well as about the highest volume of wood. The disadvantages attached to it are the large proportion of low-priced fuel obtained, and owing to the quickly-repeated growths, the demand it makes on the soil."

The methods of working and utilization pursued in the national forests generally, may be classed under two main heads, "coppice" and high forest. Coppice comprises simple coppice and coppice under standards. The latter—providing for the protection of reserved trees at intervals—to yield seed through several rotations of the growth of small timber sprouting from stools or stumps. Simple coppice, on the other hand, has no reserved trees, the whole crop of young timber being cut over in successive blocks. Coppice, owing to its short rotations

and clean fellings, yields a higher return on the capital invested in it than high forest, and it also furnishes material of greater variety than can be obtained from the latter. The inhabitants of the communes mainly require firewood and small size timber: these the coppice system supplies. Together with a modification of standard coppice it is in practice in nearly all broad-leaved forests of the communes, the high forests owned by these bodies being chiefly in mountainous parts, and consisting of conifers, which will not reproduce from the stool. The State, however, maintains more than half of its productive forests for the supply of mature timber of commercial value, its proportion of coppice being less than a third. The rotations under high forest are much longer than under coppice, and it might be expected that the returns under the former system would be less than under the latter. It appears, however, that the returns from the State forests are greater in quantity and superior in quality.

There are two local variations of simple coppice. In the Ardennes region of North-East France, *sartage* is practised. The chips and twigs left after cutting the coppice-wood are collected and burnt on the ground, the ashes thus obtained being used to manure the cereal crop, which is planted between the stools during the follow-

ing year. *Furetage* prevails in the Seine Valley, and provides most of the firewood for Paris; it also obtains in the mountain regions of Southern France, where it is not desirable to denude the cover growing on steep slopes. In this system, the whole of the coppice on a given area is not felled, but only stool-shoots of certain dimensions. The cutting is repeated every year or at intervals of two to five years. High forest, which is established and maintained to yield mature timber of large size, consists of trees raised from seed, the reproduction being also from seed which is usually self-sown. As with coppice so with high forest, two methods are pursued. In one, trees of about the same age are grouped and subjected to regular thinnings till the time arrives for natural reproduction. This is secured by a series of fellings in order to promote the formation of seed on the trees left standing, and the growth of seedlings. Ultimately, the old reserved seed trees are also cut down and removed, and then the new crop of trees, after a period of strict protection gradually goes through the same process of improvement fellings. In the *jardinage* or selection plan of working, trees of all ages are scattered over the forest area. There are no periodical thinnings, but timber is obtained by taking picked trees from a given area, on block

after block, until the whole forest is cut over. By this method a close approach to the tree-growth of a natural forest is obtained, as distinguished from the artificial conditions arising from the grouping of age-classes together.

In an average year, the total yield of material from the reserves under forest administration was, timber and wood, 5,311,516 tons; cork, 415 tons; tar bark, 3,673 tons; and resin, 2,668 tons, valued at £2,285,070. Of this amount £1,009,529 represents the yield from State forests and £1,275,540 that from communal and other public reserves.

Of the forest trees, Oak covers about 29 per cent of the total area, Beech 19, Hornbeam 12, and Silver Fir 7 per cent; then Northern Pine, Evergreen Oak, Maritime Pine, Spruce and Larch, with other conifers, range from 4 per cent downwards.

Forest produce is disposed of either by the sale of standing trees, by the sale of converted material, by measured and computed quantity or by the sale of material cut and converted by forest employés. In every case, except produce sold to the War Department, the Admiralty, to right holders, or from communal reserves to the inhabitants of communes, sale must take place by public auction. When standing trees are sold to bidders, the trees for sale are marked

and the purchaser is bound to carry out the work of felling, conversion and removal. This plan, though not much in favour in other countries, is highly favoured in France, and its maintenance is encouraged by the honesty generally prevailing in the timber trade. The second method fixes the rate for a given quantity of timber according to quality and dimensions. It is usually only adopted in the case of thinnings. The sale of timber cut by the Forest Department is seldom carried out, for the reason that the material is not always cut into sizes to suit the market requirements, a state of affairs which conduces to low prices.

Working plans for the cutting and removal of material from the State and communal forests are prepared at the head bureau in Paris. No departure from these plans is permitted without government sanction. The plans for the coppice system are simple, those for high forest more complicated.

“No sketch of forestry in France would be complete without touching on the invaluable work accomplished in fixing the drift sands on the Atlantic coast, and in replacing the denuded slopes of extensive mountain tracts in the Alps, Pyrenees and Cevennes.”

For several hundred miles along the west coast, but especially between the Gironde and

the Adour, there is a tract of country consisting of barren dunes and ridges of sand formed by the high sea winds which sweep over that region. The encroachment of these sands, advancing steadily inland, and in their course overwhelming villages, farms and roads, became so great a public danger that towards the end of the last century strenuous endeavours were made to arrest their progress. Various plans were tried, but the most successful were those adopted in 1789 by M. Bremontier, a *civil ingénieur*, who built palisades along the dunes, and then, on the landward side of these protective barriers, planted the seeds of Maritime Pine, with a mixture of Broom, Gorse and Gourbet or Marram grass, the sowing being continued in successive belts until the whole width of drift-sand was gradually brought under cover. The work thus begun was steadily pursued for many years, until to-day a great part of the dunes and *Landes*, which embrace an area of over 220,000 acres, is covered with valuable Pine forests. They yield a handsome return on the original expenditure, furnishing timber, resin, turpentine and fuel in abundance, while the more open tracts afford good pasture for cattle.

In the *reboisement* or replanting of denuded mountain lands in Southern and South-Eastern France, an even more difficult task lay before

the engineers and forest officers who were entrusted with the work. In this case widespread damage had been caused by the inhabitants themselves. When, during the revolutionary period, the laws against emigrant landowners, and the numerous confiscations which followed, caused the breaking up of extensive private estates all over France, a general change in tenure, by the creation of a very large class of peasant proprietors, was the result. Naturally these small owners sought to utilize every rood in their holdings for tillage and pasture, and when, as was especially the case in the Alps and Cevennes, their allotments were in forest regions, they soon sold or burnt the timber, while their flocks destroyed the shrubs and undergrowth. Disaster quickly followed. Immense tracts of hill slope and upland became arid and desolate wastes. Under the sweep of heavy rains the soil was first washed down to the plains and valleys, and then the loose stones and pebbles, until nothing remained but stretches of naked rock scarred with deep chasms and fissures, down which torrents of storm water poured, flooding the lower country and carrying down masses of debris to be deposited on the fertile valleys and flats along the courses of the streams. At last the general government was forced to adopt remedial measures, and at an

early stage of the investigation which took place it was found to be necessary to bring these denuded regions under strict forest control.

A beginning was made by erecting stone barriers or terraces on the slopes, and along these collecting sufficient soil for the planting of binding grasses, shrubs and tree seeds. On the higher levels, strongly rooted trees such as Pines, Larches and Firs were thus planted, in order that their dense foliage and thick deposits of leaves and needles on the surface might form an effective cover to retain and gradually distribute the water of the heavy rains and snows which fall in these districts. On the lower and more sheltered parts the Cork Oak, Chestnut and Carob were largely planted, preference being given to finest bearing species as far as possible. Under the law in force since 1882 these reclamation works can be carried out either by the State or by the proprietors, the latter being chiefly the village communities. When, after careful examination, it is considered necessary that a private area should be replanted, the State can take the land either by agreement or as a compulsory measure, compensation being paid to the owners. The area is then under forest law, and the works are carried out at the cost of the State. Should the owners wish to keep the land they must undertake the reclama-

tion themselves within a fixed period, and, if necessary, they are assisted with financial aid, or with seeds, plants, and labour. The work in all cases is under the supervision and control of the Forest Staff. As a further safeguard the practice of grazing sheep and cattle in these regions is very strictly regulated, the communes being required to furnish the prefects with full information concerning their pasture lands and the number of live stock they propose to place thereon. The allotment and duration of grazing is subject to modification by the forest officers, and, where the public interest demands it, this power is strictly enforced. Up to 1891 this extensive scheme of reafforestation had cost the State over two millions sterling, and about half of this sum had to be expended in engineering works to render possible the replanting of the watershed areas of mountain torrents.

In the colony of Algeria forestry is pursued with the same care as in France. The total area under forest in this province is 8,119,000 acres, but nearly a quarter of this area is situated in districts remote from settlement, and is, therefore, not utilized at present. The State owns 4,398,000 acres; 192,000 acres belong to communes and 1,170,000 acres to private persons. A considerable extent of the land under forest bears inferior timber, and the value of the annual

yield is comparatively small. The principal trees are several species of Oak, including the Ilex, which yields excellent tanning bark, Maritime and Aleppo Pines, Elm, Ash, Poplar, Wild Olive and Thuya, a fine conifer greatly prized for cabinet work.

The most important return from the State reserves is from the extensive belts of Cork Oak. In 1898, 5,270 tons of cork were obtained from these lands.

Germany. More than a quarter of the total area of Germany is forest land or a total of 35,000,000 acres. In the mountainous regions of Central Germany the proportion of wooded area is 31 per cent, on the northern plain 24 per cent, and on the coast only 15 per cent. In Prussia, Saxony and Bavaria, and some of the smaller states, about half the forest land belongs to private owners ; in fact one-half of the forest land in the whole of the empire is privately owned ; one-third belongs to the State, and one-sixth is the property of towns and other municipal bodies.

The State reserves in Eastern Prussia cover approximately 60 per cent ; in the western and southern parts of the kingdom private and communal ownership obtains. Many of these communal forests are of considerable extent and

well managed; they frequently prove such valuable property that the governing bodies are enabled to give substantial relief in taxation. The forest of Goerlitz, in Silesia, which comprises 75,000 acres to a population of 62,000 inhabitants, is a noted instance of a revenue-yielding area of this nature.

Of the German forest trees, Pine prevails in the north and north-east; Larch, Spruce and Fir in the south; Beech and Oak in the western and south-western regions, and mixed forest prevails in the centre part.

Conifers cover more than 65 per cent of the total forest area, and deciduous trees 34 per cent. Of the conifers 42 per cent is Pine, 22 per cent Spruce and Fir, and Larch under 1 per cent; amongst deciduous trees, Beech covers 14 per cent, Oak 3·5 per cent, and coppice, with standards, covers 6·5 per cent, the remainder being mixed forest and coppice.

From her forest lands Prussia obtains a gross revenue of £2,800,000 and a net revenue of £1,200,000, and the other States, after paying all expenses, had the following surplus: Bavaria, 2,300,000 acres, £546,000; Würtemberg, 470,000 acres, £247,000; Saxony, 416,000 acres, £342,100; and Baden, 235,000 acres, £137,000.

The average cost of management and control

182 TIMBERS AND THEIR USES

is about 40 per cent of the gross revenue ; of the total expenditure for this purpose, 30 to 40 per cent is set down for salaries, the same proportion for timber-cutters employed on daily wages ; 15 to 20 per cent for forest roads and tree-culture, and a percentage varying from 10 to 25 for sundries.

Reforms in the German forest service were instituted by Frederick the Great soon after the commencement of his reign. At first the French method of dividing the forest areas into equal-sized compartments was followed. This, however, soon gave place to a scheme designed to secure the continuous and regular productiveness of the forests, together with a closer correspondence between the quantities of timber removed and the revenue obtained. The Ordinance of 1836, with certain modifications, is still the main guide in forest practice.

When a new forest is purchased for the Crown, or brought under State management, the first step taken is to have it carefully surveyed, its boundaries marked and recorded, and blank maps prepared, showing its limits. Next comes the division of this area into compartments or blocks, these being marked on the ground as well as laid out on the maps. Then these blocks are grouped into sub-districts or ranges (in many cases about 10,000 acres), which will form units

in the scheme of management and working. Next, a full description is prepared of the extent, the plan of division, the boundaries and the legal rights attached to the forest. Then comes a general description of the configuration, climate, soil, forest growth, the plan of treatment hitherto pursued, the conditions of the local timber market, and the current wages paid. All this information is accompanied by reference to the sources from which it is obtained, and this record, when complete, forms the material from which the new plan of management is drawn up by a Commission. In preparing this plan, with its descriptive record, full particulars are given of the division of the forest into compartments and blocks or ranges, and the reasons therefor; also of the form of management for each block, or part of a block, whether high forest, coppice, standard coppice, etc.; the length of the rotation or cutting period, and the methods to be pursued in carrying out fellings and thinnings; the estimated annual yield, and the period within which the forest is to be brought under a regular and systematic course of management. Such a record, it is obvious, requires very careful examination of the stock of growing timber, and it is here that the duty of the valuator comes in. He examines and describes the class and

quality of soil, with its capacity for the growth, taking the land by ranges and even compartments, if there is much variation. The dominant timber, or if it is an evenly mixed forest, that kind on which the working is to be based, is noted, and the average rate of growth ascertained, for the purpose of grouping the belt or parcel into "age classes," which usually comprise twenty years, so that the growth of 1 to 20, 20 to 40, 40 to 60 years, etc., forms a distinct class for utilization. The valuator also carefully records the density of growth and all thin or open spaces. He is further required to form an opinion on the spot as to the best mode of treatment for each parcel, as regards its promise and fitness for early or late fellings, and to estimate the thinnings which should come out during a period of twenty years. From this information a table is prepared showing the area of each parcel, according to its age or "age class," and this again forms the basis for a complete timber map, showing the existing conditions of the forest, the dominant timber in each parcel being marked by different colours, mixed trees by signs "and the age of trees by shades of colour."

On the completion of this work plans for the future arrangement of the age classes is taken in hand, so that when the forest is brought into

proper working order, areas of approximately equal production may be regularly cut. Cutting is contrived so that the trees may not be unduly exposed to wind storms. Considerations of drought, fire, disease and insect attack are not forgotten. The yield calculations are also taken into consideration, also from the general plan thus prepared, a special plan is formulated for the first period or half-period, dealing with felling, planting, road making, etc. On this plan the forest officer prepares his annual working plan, which is subject to revision by the controlling staff.

The course of training essential to candidates for the forest service is severe and comprises theoretical work in schools and universities, combined with practical work in the forests. After passing the ordinary examinations at the gymnasium or realschule, the student goes for six or twelve months into the woods to learn the general outlines of forestry work. Next he goes for two and a half or three years to a forestry school, where he undergoes a course of theoretical and practical work. The chief forestry schools are at Eberswalde, Münden, Aschaffenburg, Tharand, Karlsruhe, Giessen, Eisenach and Tübingen. From the technical school he goes to some university to learn jurisprudence and political economy, and he

then comes up for his first examination. He must produce his plans and field notes of a plot surveyed, and a level run, and also a timber map covering an area of at least 1,235 acres. The examination includes, under forestry, a thorough knowledge of the general principles of silviculture, working plans, calculation of the volume and yield of standing timber, the capital and sale value of timber, utilization of forest material, forest technology, protection and police work, forest history and literature. The other subjects are mathematics, botany, zoology, mineralogy, chemistry, physics and law. After passing this examination, the candidate, who is now known as a referender, must devote two years to the study of forestry practice in various districts. During this period he is required to keep a complete diary of his work and observations, which must be certified by the district forester, and forms part of his final examination.

Nine months of his time is spent in the regular discharge of a forester's duties, and part of his time he carries out the duties of a district forester. The last course is that of law at a university, and this may extend over two years. At length he presents himself for the final examination, a searching ordeal which lasts from eight to ten days and is carried out partly in the forest. The successful candidate becomes a

forest assessor and his name is placed on a waiting list. He may have to wait for eight or ten years before he is appointed a district forester, but during this period he is usually given some administrative or scientific work on daily wages, such as the making and correction of valuations, or in laying out roads, acting as tutor and relieving or assisting district foresters. The higher offices are filled by selection, length of service being considered only where it is united to special fitness. The pay is not high, but the position is a permanent one and carries the right to a pension. The director or oberland foistmeister only receives £720 per annum.

That the German forest organization is efficient there can be no denying, and the present standard has only been attained after generations of patient effort and labour seconded by the people of all ranks.

Switzerland. Efficient forest management around the city of Zurich has been in practice for nearly five hundred years, but, throughout Switzerland generally, forestry was only developed about the middle of the eighteenth century. Between 1780 and 1790 several of the cantons appointed forest officers with duties as examiners of State and communal forests. At this time large tracts of public forest were

surveyed and subdivided into compartments for securing a good system of working. Regulations were drawn up, but the forest service was impeded by the revolution of 1798 and the following years. Schemes for reforesting were set on foot.

The condition of the mountain forests at this period was deplorable. All over the country extensive areas had been destroyed or greatly damaged by unregulated fellings, and the young growth injured by the ravages of flocks and herds. In 1834 great floods caused further damage in the Alpine regions and forced the people to devise methods to prevent a recurrence of the inundations. These destructive floods were largely caused by the felling of the trees on the mountains. The work of reafforestation was taken up in earnest; stringent forest laws were passed, supervision was redoubled. The Swiss Forestry Association was instituted in 1843, and a Forest School was founded at Zurich in 1865. In 1876 the first general forest law was adopted.

All the Swiss laws require the same treatment for State, communal and private forests; in the last named, however, supervision is less strict than in the others. Owners may not reduce the area of their timber land without the consent of the cantons; they must replant where there is no natural growth and take care of the grow-

ing stock. On lands classed as "protection forests," all timber to be cut by private owners is marked by government officers in order that wasteful or careless cutting may be prevented.

"One of the most remarkable instances in Europe of successful communal management is that of the Sihlwald, which belongs to the city of Zurich. With an area of only 2,400 acres this forest, in the year 1889, gave a return of over £1 13s. per acre, or £4,000 for the whole property. Its working is so regulated that areas of equal productive capacity are covered by stocks of every age from the seedling to the mature tree. The age gradations, it is said, are so regular that in the course of an hour's walk one may pass from an area just cut over through compartments of steadily advancing age and growth, till the trees which have attained the full age limit of ninety years are reached. The forest is managed under different plans of working, and while great care is taken to secure a large annual yield, it is not obtained at the expense of the permanent productiveness of the forest, the precaution to insure regular regeneration being studiously observed. While the conditions of soil and moisture are favourable, it would not be easy to account for the exceptional productiveness of the Sihlwald, but for the fact that the land has been continuously

under forest cover for over a thousand years. Hence it has that great depth of alluvium and rich vegetable mould which can never be furnished by denuded or partly denuded lands, covered intermittently with forest, but which, when existent and combined with suitable climatic conditions, produces the finest tree growth."

The federal forest law of 1876 applies to almost two-thirds of the country. Under the authority of this measure the confederation exercises supervision over all protection forests situated on the slopes of hills and mountains, or along the courses of streams, as well as over all other State, communal and corporation woodlands. The burdening of the woodlands with new prescriptive rights, such as pasturage or leaf gathering, is forbidden. All forests are to be surveyed, their management brought under strict regulation and working plans for the utilization of timber, regeneration and replanting drawn up. The Inspector-general of Forests sees that the act is enforced.

Italy. There are 10,131,000 acres of forest land in Italy, or about 14.31 per cent of the area of the country ; the annual yield, including useful timber, fuel, charcoal and secondary products, is valued at three and a half millions

sterling. The forests are divided into two classes, those belonging to the State embracing nearly 426,000 acres, and those belonging to communes, corporations and private owners to the extent of 9,705,000 acres. Barely half of the forest is subject to the general provisions of the forest laws. In the communal reserves the inhabitants have in nearly all cases the right of pasture and of getting wood for domestic purposes, but grazing is only allowed when the trees are of sufficient height to be free from the danger of injury by trampling or browsing.

The Department of Agriculture, Industry and Commerce supervises the general forest management, but the immediate supervision is in the hands of the provincial forest committees. Each of these bodies comprises a prefect, who acts as president, a forest inspector of the province, an engineer and three other members. These committees make regulations for the protection and working of the forests in their province, and deal with all applications for the conversion of forest into cultivated land.

The State forestry school is situated at Vallambrosa in Tuscany, and is under the direct control of the Minister of Agriculture. The entrance examination to this school comprises Italian, French, German, natural science, geography, arithmetic and algebra. There are

two classes of students, those who wish to serve as forest inspectors and those who wish to study forestry for their own benefit.

The course of study embraces the languages and literature of Italy, France and Germany ; botany and zoology ; physics, chemistry, geology and agriculture and their applications to forestry ; topography and surveying ; forest management and working, including silviculture and reafforestation work and forest legislation, with the elementary principles of the general law.

The decay of the forests in many parts of Italy has become a matter of grave public concern. It may be traced to several causes, but unquestionably the prime cause has been the large increase of population during the present century, and the practice of occupying for tillage the poor and scanty soil on hillsides and other elevated situations formerly covered with trees and shrubs. This disregard of a great natural law, in stripping the hills of their tree cover, produced the same evil effects as in France, the denuding of the crests and slopes being followed by landslips, torrents and devastating floods, while the accumulation of immense masses of *débris* in the valleys caused great damage to arable and pasture lands. Other causes of decay may be found in the reckless clearing of seed trees, and the ravages

of large flocks of goats, which in many districts were allowed to browse on the young trees and shrubs. At length the Central Government at Rome determined to endeavour to check the widespread evils resulting from the destruction of the woods, the first step being to adopt a stringent law for their protection, which came into force in June, 1877. Since then a great deal of planting has been carried out on public as well as on private lands, and in the reafforestation of denuded mountain and hill slopes considerable progress has been made in several of the provinces.

Austria-Hungary. The total forest area of this country is 42,256,000 acres; 24,468,000 acres, or 32 per cent of the total area, being in Austria, and 17,788,000 acres, or over 23 per cent of the whole area, belonging to Hungary.

In Croatia and Slavonia there are approximately 3,800,000 acres under forest. In Austria over 17,000,000 acres are under Pine trees of various kinds. In Hungary 5,000,000 acres are under Oak, over 9,000,000 acres under Beech, and 4,000,000 under Pine.

The forests are under the control of the Department of Agriculture, and great attention is paid to the efficient training of forest officers. In Austria alone there are no fewer than 137

schools of forestry and agriculture, and an excellent high school is situated at Vienna. The courses of study are closely modelled on those of Germany. The forest officers direct the manner and rotation in which timber is to be cut, the prevention of waste, the carrying out of replanting work, the preservation of timber as a safeguard from floods and landslips, and the taking of protective measures against destructive forest insects. "This system of paternal control has, it is said, as a rule, achieved excellent results, although there is the drawback that, in some instances, the law is administered with laxity and in others with great strictness."

"A striking instance of the effect of forest denudation is seen in the Karst, an extensive region of mountain slope and tableland stretching along the Northern Adriatic, and consisting chiefly of grey limestone interspersed in parts with oxide of iron, which gives it the appearance of red volcanic soil. This tract of country, whose natural wooded area is now confined to a few deep valleys, still a picture of richness and fertility, was originally covered with immense forests of the finest Oak, and even before the Christian era was resorted to by the Romans for timber for their ships and houses. Through subsequent centuries it continued to be one of

the chief sources of supply of the maritime nations of the Mediterranean for shipbuilding, until during the long period, when the Republic of Venice controlled the Adriatic coast, the work of destruction was gradually completed. When the mature timber was removed, the inhabitants set to work on the young trees as well as the stumps and roots, and such young growth as was unfit even for fuel was soon destroyed by their flocks and herds. With the removal of the forest cover, the work of erosion by wind and weather quickly began. The soil was first swept away, then the exposed limestone rock broke up and pulverized, great fissures and dolines or funnel-shaped holes opening along the hillsides, into which the surface waters of the winter rains and melted snows poured and were carried off by underground channels. So, gradually, what was once a fertile region, enjoying a mild temperate climate, became an arid and desolate waste. Exposed on the north to the cold winds which blow over the snow-capped heights of the Austrian Alps, and on the south to the African sirocco, this denuded tract is remarkable for gales of extraordinary violence which sweep over it. The Austrian Government has, with great energy, entered on the work of reforesting selected portions of it,

and many millions of trees have been planted, the inhabitants in some instances being compelled by law to give their labour free in this work, or to contribute to the cost of it. An undertaking of this kind must, obviously, be slow and costly, and despite these praiseworthy efforts to repair the destruction of past centuries, the Karst remains one of the most desolate regions in Europe, tenanted chiefly by flocks of miserable sheep and goats."

Sweden. The total area under forest is 47,000,000 acres, one quarter of which belongs to the State. The most valuable and the most widely distributed timber trees are the Northern Pine and White or Norway Spruce. Next comes White Birch, which furnishes the principal fuel of the country, and in the southern part of the kingdom Beech flourishes. The exports of forest produce generally, produce over ten millions sterling per annum, an output which is steadily increasing, owing to good management.

There is an admirable forestry school in Stockholm and various minor institutions throughout the country.

The average value of timber shipments annually from Sweden amounts to £10,000,000, upwards of half going to Great Britain.

WORLD'S TIMBER RESOURCES 197

Norway. The Norwegian forests cover approximately a quarter of the country, or 19,300,000 acres, of which 73 per cent is under Pine trees. The Crown forests occupy 2,315,000 acres, municipal forests 578,000 acres, and private forests 16,395,000 acres. Owing to the enormous exports, the timber resources of Norway are steadily declining. One of the chief sources of waste was found to be the felling of young trees for pulp.

In 1893 an act was passed for the demarcation and maintenance of "protection forests" on mountain slopes and watersheds, the object being to ensure efficient protection against landslips, drifting sands, and alterations in the courses or beds of streams.

As the majority of the forests are in private hands, it is not surprising to find that the proportion of those worked on forestry principles is very small, being only 276,000 acres. The annual output clearly exceeds the natural increase, hence not only is the supply of timber and fuel decreasing, but the average size of the trees felled is also becoming smaller.

In connection with planting work, three large nurseries and several smaller ones, as well as four seed establishments are maintained, which supply trees and seed to private persons as well as to public bodies.

Russia is one of the largest timber exporters in the world. European Russia possesses 422,307,000 acres of forest land or nearly one-third of the whole country. Poland has 6,706,000 acres, Finland 50,498,000 acres, and Caucasia 18,666,000 acres. There is, in addition, an enormous tract of forest land in Asiatic Russia to be brought under control.

Sixty years ago suggestions were made and plans formulated for the better administration of the Russian forests, but not till twenty years later was the existing organization established.

There is a Forestry Institution in Petrograd and another at New Alexandria in the Vistula provinces, and there are chairs of forestry at a number of schools and colleges. Forestry is also taught in many of the lower schools.

The United States of America. About one-quarter of the whole country, or rather less than 500,000,000 acres, is forest land in the United States. Distribution is uneven, seven-tenths of the forests are on the Atlantic side, one-tenth on the Pacific side, a tenth on the Rocky Mountains themselves, and the remainder scattered over the States between the Rockies and the Mississippi. The diversity of growth is also very marked and is dependent on climate and altitude. On the Pacific coast there are very few hard woods,

the principal trees being conifers, such as Redwood, Douglas Fir, Larch, Bull Pine, Cedar, Hemlock, Sugar Pine, and various other Pines and Spruces. In the Rocky Mountains the trees are chiefly Bull Pine, Firs and Spruces, with other Pines and Cedars. The southern regions of the Southern States are covered with Pine forests, with Cypress on the lower lands, but their northern parts bear hard woods almost exclusively, with mixed hard woods and conifers in the central districts. The Northern States are rich in hard woods mixed with conifers.

According to a recent census, the estimated value of forest produce used in a year was over £200,000,000, the industries connected with the preparation and sale of timber, by-products, and manufactures of timber being second only to agriculture, and exceeding in value the products of mining by more than 50 per cent. While more than a million persons were employed directly or indirectly in connection with the former industries. Forest fires do damage which averages £5,000,000 per annum.

“White Pine” is now chiefly confined to the Lake States of Michigan, Wisconsin and Minnesota, especially the two latter, and owing to the increasing dearth in some of the markets, large supplies of logs cut on the Canadian side are towed over and sawn up at American mills.

200 TIMBERS AND THEIR USES

The Red or Norway Pine is still found associated with the White Pine in considerable quantities. Bull Pine is the principal hard Pine used in the Pacific and Western States, while soft lumber is obtained from the gigantic Sugar Pine.

“From the coniferous areas of the Southern States come large supplies of the Long Leaf or Georgia Yellow Pine, the Cuban or Slash Pine, the Short Leaf and the Loblolly or Virginia Pine. Nearly all these are sold in foreign markets under the name of Pitch Pine. Spruce and Fir are chiefly confined to the North-western States and the Rocky Mountain region. This lumber has superseded Pine for joists and light construction, and the annual cut is very large, five-sixths of the annual output in Maine being now Spruce. Douglas Fir (commonly known as Oregon Pine) is the dominant tree in the North-western States of Washington and Oregon, forming about seven-eighths of the forest growth. It is also found further eastward in Idaho. The standing timber in Washington was, in 1896, estimated to cover over 23,000,000 acres. The principal markets for the timber of this region are San Francisco, South America and Australia. Hemlock is obtained chiefly in New York and in Pennsylvania, the bark being used for tanning and the timber as a substitute for White Pine in rough construction. Red Cedar has a wide range, but

supplies chiefly come from Tennessee, Alabama and Florida. This timber is used for hollow ware, such as buckets, etc., and for lead pencils. Five million feet are used annually in bucket factories, and about 500,000 feet for pencils. The fine Redwood of commerce is found only on the coast range of California, the standing timber available being estimated at 25,000,000,000 feet b.m. (100 feet b.m. = 8·3 cubic feet). There are fifty species of Oak in the United States, and of these about a dozen are cut for timber, being sold as White and Red Oak respectively. At one time only the white variety was cut, it being used almost wholly for construction and cooperage work. Oak is now employed in large quantities for furniture, panelling and interior decoration, and the annual output has increased to about 3,000,000,000 feet, the principal sources of supply being Kentucky, Tennessee, Arkansas and West Virginia. The various species of Hickory, one of the finest American hard woods in point of strength and toughness, are chiefly devoted to coach building work of all kinds, tool and implement handles, etc. The timber now comes from Kentucky and Tennessee, the vast Hickory forests of Indiana being exhausted, while in the Eastern States it has also become very scarce. Ash is obtainable in large quantities in Tennessee and

202 TIMBERS AND THEIR USES

Kentucky, and, to a less extent, in West Virginia, Michigan and Wisconsin. Although the annual output of this timber is considerably less than it was twenty years ago, it is still large, being estimated at 350,000,000 feet. Poplar and Cottonwood are chiefly cut in the Central States last mentioned, east of the Mississippi. The latter tree has a very wide range of distribution, and has not long been in the market as a commercial timber; it is largely sold as ordinary Poplar, the wood having a tendency to warp in drying unless carefully seasoned. It is, however, regarded as a timber of very fair quality. The annual output of these two timbers is estimated at over 700,000,000 feet. The American hard woods which are used in cabinet and joinery work are numerous and of very fine quality. In addition to Oak and Ash, there are Birch, Elm, Black Walnut, Maple, Cherry and Sycamore. Birch is plentiful in the Alleghanies and the lake region, West Virginia, Maine and New York. It makes very handsome furniture, the black variety being very largely used for this purpose. Black Wild Cherry, obtained chiefly from West Virginia and Tennessee, is greatly prized for cabinet work. Black Walnut, one of the finest of furniture woods, has almost disappeared from the market. It grew in large quantities along the slopes of valleys of the

Mississippi basin. Both in Canada and the States the settlers used it extensively for fences, slabbing work, hog pens and rough buildings generally, as well as for fuel. Its destruction in this fashion, and the requirements in later years of the home and export trade, have brought about the exhaustion of the mature timber in most states. Its scarcity in Kentucky, Tennessee and Missouri is shown by the fact that it is now sold at a fixed rate per tree. Sycamore and Elm are plentiful along the basins of the Ohio and Lower Mississippi; the Maple attains its best development in the Northern State of Michigan. It is used for flooring, furniture and interior panelling of houses and railway cars."

The greatest and most valuable forests in the world are those of the United States; nevertheless, there is no country which has permitted such enormous destruction and waste of its timber. But little of the forest land is controlled by the State. The opposition of lumber men, of graziers, of all those in short whose temporary interest lies in the misuse or free occupation of forest lands has been successfully concentrated in obstructing or securing the withdrawal of all protective measures.

The existing government reserves lie in eleven states and cover 40,719,000 acres; the most extensive are Arizona, Grand Canyon reserve

204 TIMBERS AND THEIR USES

1,851,520 acres ; California, Siena reserve 4,096,000 acres, and Pine Mountain and Jack Lake reserve 1,644,000 acres ; Idaho and Montana, Bitter Root reserve 4,147,200 acres ; Montana Lewis and Clarke reserve 2,296,000 acres ; Oregon, Cascade Range reserve 4,492,000 acres ; Washington State, Washington, Olympic and Mount Rainai reserve 8,077,920 acres ; Wyoming, Yellowstone National Park Timber Land reserve 1,239,000 acres.

Seeing how progressive the United States has always proved in the domain of agriculture, one would expect to find the same spirit ruling in her forest service, but this is not the case. Despite a very large number of excellent bulletins and publications relating to forestry issued by the State, she has never shown the same care of her standing timber as have many European governments.

Canada is the chief timber-growing colony of the British Empire. Nearly 38 per cent of the total area of the colony, or 1,248,700 square miles, is forest land, the largest areas of timber being in Ontario, Quebec and British Columbia.

Among the articles of forest produce exported to foreign countries, White Pine and Spruce, in the log, in small balks and sawn into lumber, come first, while among the hard woods, Oak,

Elm, Hickory, Butternut, Ash and Maple are shipped in considerable quantities. In the eastern and central provinces White and Red Pine and Spruce are the dominant trees, while in the Rocky Mountain region and in British Columbia generally Douglas Fir (Oregon Pine), four varieties of Spruce, Red Cedar and Yellow Cedar or Cypress, take their place.

“Speaking generally, the enormous drafts made by the large export trade of Canada have denuded of mature timber very extensive areas in Nova Scotia, New Brunswick, Quebec and Ontario. This applies more particularly to White Pine, which has been the chief timber exported during the past fifty years. From a careful investigation made by the Dominion Government in 1895, it appears that Pine of the first quality has nearly disappeared from the forests, but that of the second quality there is still a considerable supply. Of other commercial timbers, however, such as Spruce in the east and Douglas Fir or Oregon Pine and Cedar in the west, there is a large supply. The conclusion arrived at, after examination of the evidence and information obtained, was that the Dominion is within measurable distance of the time when, with the exception of Spruce as to timber, and British Columbia as to provinces, it must cease to be a timber-exporting country.

The causes of the increasing scarcity of Pine in the eastern provinces are not far to seek. In addition to the export trade and the requirements of the home market, the inflammable nature of the Pine, as well as Spruce, renders it liable to enormous conflagrations in the summer season. The carelessness of settlers in clearing the land, and of hunters, trappers and anglers in making camp fires, has brought about the destruction of many hundreds of square miles of forest, and competent observers have expressed the opinion that immensely larger quantities of valuable timber have been destroyed in this way than by the inroads of the lumbermen. Most of the provinces have, it is true, adopted fire-protection laws with stringent provisions, which have had the result of making settlers and lumbermen more careful in the use of fire, but conflagrations still break out in hot and dry weather, and when once they spread in Pine country it is very difficult to check or extinguish them.

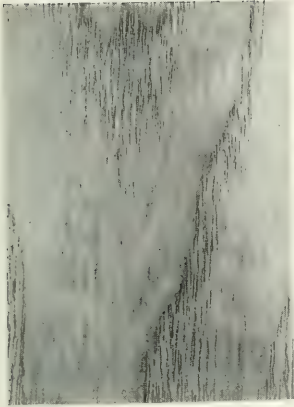
“To sum up the present position, it may be said that Eastern Canada in the maintenance of the export trade, is drawing heavily on the capital of the forests, and that the destructive forces at work are vastly greater than the production. In a country where the production of timber and the by-products of the forests is

one of the chief industries, and where there are still extensive supplies of second-class timber untouched, it is difficult to induce the public to agree to such restrictive measures as will insure reproduction and continuous supplies. As the natural reproduction of conifers is from seed and the White Pine does not grow as rapidly as some other soft woods, it is plain that sooner or later the strictest protection must be enforced in denuded areas while forests more remote from the settled districts are being worked, in order that fresh supplies may be insured. Under favourable circumstances fairly mature White Pine may be obtained in 40 years, although a better quality of timber from trees about two feet in diameter may be looked for in 60 to 70 years."

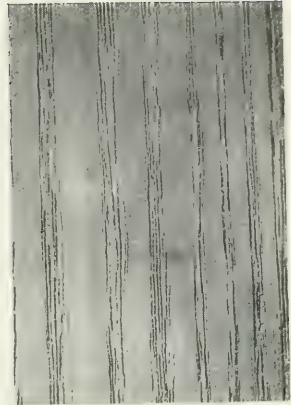
Ontario boasts about 23,000,000 acres of forest land, and despite the very extensive lumbering operations which have been carried on for many years, the province still has very large supplies of merchantable timber.

"The principal tree of commercial value is the White Pine, the timber of which, in addition to a large consumption in the Dominion, is one of the principal articles of export to Europe and the neighbouring republic. It grows both in pineries and mixed with other trees, and is found chiefly in the valley of the Ottawa River

and its tributaries, and along the streams flowing into the great lakes. The height of land in the northern part of the province, which forms the watershed between the rivers flowing into Hudson's Bay and those flowing southward into the lakes, marks the southern limit of the White Pine, beyond which its place is taken by Spruce. The Red or Norway Pine, a less valuable tree for lumber, but largely used for building, and for masts and spars, is found in the same regions as White Pine, but the quantity available is smaller. Spruce is abundant, its habitat being chiefly to the north of the White Pine region in Ontario, while it extends from the eastern provinces to the Pacific. The demand for Pine being so great, this tree is at present somewhat neglected by lumbermen. The white variety of Spruce is used largely for floors and joists, doors, sashes, mouldings and panelwork wherever Pine is scarce. The black variety is chiefly used for the manufacture of wood pulp for paper, and this being an important article of export great inroads are made on the Spruce forests in the pursuit of the industry. The Hemlock Spruce is also cut in immense quantities. It is largely used for railway sleepers, and provides cheap lumber for the interior of buildings, as well as cordwood for fuel. Its main use, however, is for its bark, which is the principal tannage



49. ENGLISH ASH.



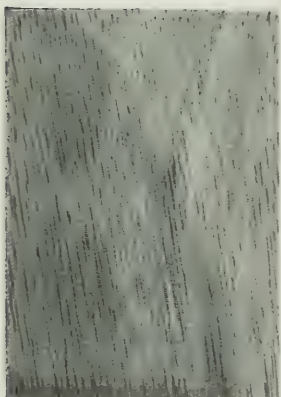
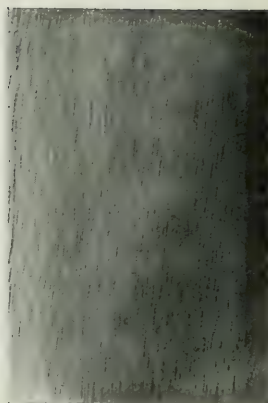
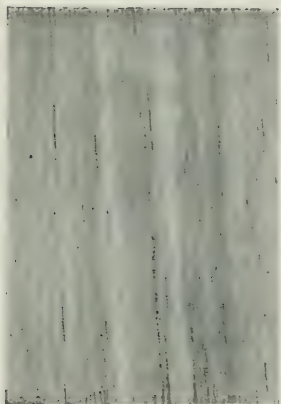
50. JAPANESE ASH.



51. AMERICAN ELM.



52. ROCK ELM.



53. CROW'S FOOT ELM.

55. ENGLISH WALNUT.

54. AMERICAN WALNUT.

56. BEECH.

of Canada and the States, and is stripped in enormous quantities both for the home market and for export."

Hemlock, Tamarack or Larch, Cedar and Balsam Fir are plentiful, but while this timber is in local use it is not exported to any great extent.

Tamarack, a deciduous tree, is little inferior to Oak in strength and durability. It was formerly largely employed in shipbuilding, and at present, despite the decline in this industry, it is still in use for local vessels and scows. It is also employed for the planking of sidewalks and footpaths in Canadian towns. The smaller trees are cut up for railway sleepers and cordwood, it being an excellent fuel for steaming purposes.

The hard woods are of great variety, and are widely distributed throughout the central and southern parts of the province. The principal kinds are Oak, Elm, Maple, Beech, Butternut, Hickory, Basswood or Linden and Cherry, with some Black Walnut, but the latter is becoming very scarce.

In British Columbia 75 per cent is under forest. It has been estimated that, based on an average output, the existing timber supply will last for over 150 years without taking the natural reproduction into account. No nurseries or

plantations are maintained, the climatic conditions being such that the forest renews itself immediately after the timber workings are deserted. Indeed, it is only by constant labour that the encroachments of the young growth on cultivated areas can be prevented. Forest fires are a source of considerable loss despite a stringent Bush Fires Act.

“Among the trees of commercial value, the fine Douglas Fir, which sometimes attains a height of 300 feet, and a basal girth of 50 feet, ranks first. It is widely distributed, stretching from the coast eastward to the Rocky Mountains. With about the same specific gravity and strength as Oak, it has a wide range of usefulness, being largely employed in ordinary building and construction, as well as for bridges, jetties and shipwright’s work. Next come the Red and Yellow Cedars, the former attaining the greatest girth of any British Columbian tree. They are used for general building purposes, furniture and panelling work, the red variety being the favourite tree of the settlers in erecting their houses and fences.”

Among the Spruces, the most useful is the White Sitka variety, which has a girth almost equal to the Douglas Fir, but does not attain the same height clear of the branches. It makes good dressed lumber, and is largely used for

doors, windows, barrels, salmon and fruit boxes. It also provides good material for paper making. The Western Black or Englemann's Spruce is also an excellent timber tree, the material cut from it being tough and durable. Hemlock is found in the coast region in large quantities ; but, being used for the same purposes as Douglas Fir, it will not come into general use till that timber is exhausted. A White Pine (*P. monticola*) gives a valuable timber, but the quantity is limited. Among the hard woods the principal kinds are Maple, Alder and Arbutus, which furnish beautiful material for furniture and cabinet work. Nearly all the latter class of trees are found in river valleys and on good soil, occupied, or likely to be occupied, for settlement as the population of the province increases. The forest wealth of British Columbia lies in its conifers, its magnificent Firs, Cedars, Spruces and Pines ; and probably no country in the world has greater supplies of this class of timber. Already large shipments of Oregon or Douglas Fir are regularly made from Burrard Inlet to Australia, "and as the Scandanavian supplies begin to fail, the demands on British Columbia will be very heavy."

Cape of Good Hope. The forest lands of the Cape under the Crown amount to little more

212 TIMBERS AND THEIR USES

than 500,000 acres. This small forest area is accounted for by the fact that the nomadic natives have, for years, been in the habit of burning vast areas of forest in order to secure a new growth of grass for their herds; moreover this method of clearing was copied by the early European settlers. The work of reafforestation is now progressing rapidly after having been organized by Count de Vasselot of the French Forest School at Nancy.

Large quantities of timber are imported into the colony. Pine and Spruce from Sweden, Norway and North America; Kauri Pine from New Zealand; Karri and Jarrah from Western Australia and Messmate from Tasmania.

“For a considerable period great attention has been devoted to plantation work. In addition to conifers, such as the Maritime, Monterey, Aleppo, Canary Island, Pitch and Northern Pines, Australian Eucalypti and Wattles have been largely planted, both in the State reserves and on private lands. Among the two genera last mentioned are Blue Gum, Jarrah, Karri, Sugar Gum, Red Gum, Yellow Box, Mountain Ash and New South Wales Mahogany. The Blue Gum is more extensively planted than any other Australian hard wood, its quick growth on suitable soil and early yield of timber making it a favourite with both foresters and settlers.

Among the Wattles, the black feather-leaved and best Australian varieties (*Acacia decurrens* and *A. saligna*) succeed best, and in many districts they have displaced the other varieties, although both the Golden and Silver Wattles are grown in some parts. In the Transkei alone over twelve and a half million forest trees have been planted, more than a million of these being Black Wattle. Of the private plantations of this tree, the largest are owned by the East London Wattle-bark Company, containing 300 and 700 acres respectively. The produce of these and other plantations now supplies the tanneries of the colony, and a considerable quantity of bark is also exported to Great Britain. The local demand for tannages is to some extent met by using the leaves of the Cape Sumach (*Osyris compressa*) which, it is considered, produces a finer and lighter coloured leather than Wattle bark. . . .

“ In the neighbourhood of Port Elizabeth the example of France and Germany has been successfully followed in reclaiming tracts of drift sand. In a little over four years some 2,500 acres have been planted with the West Australian and Cyclopiis Wattles, Pypgrass and Rushy Seawheat grass, the seed being sown broadcast and then covered with town refuse. The refuse is conveyed by means of a light railway to

different depots on the sands, and then spread by convict labour. The trees and other vegetation have made rapid growth, and are forming dense plantations. In this way the plantations not only fulfil the important function of binding the sands, but they have transformed the appearance of a bare and unsightly coast, and bid fair to supply in the future, under proper care, considerable supplies of small timber and tanning bark."

Natal. In this colony there are approximately 2,000,000 acres of heavy forest, scrub and Mimosa. Little appears to be done to preserve the trees, and considerable quantities of timber are imported, notably Pine and Spruce from Europe and America, hard woods from Australia, and Kauri Pine from New Zealand.

India. About 8·5 per cent of the country is reserved forest land, or approximately 75,294,000 acres. "There is no chapter in the history of British rule in India more interesting than that which tells of the efforts made to rescue the forests of the country from destruction, of the opposition met with, the obstacles overcome, and the success achieved."

Seeing that there are upward of 1,200 species of trees in India, many of them important from

a commercial point of view, it is clear that the timber question of the country is a big proposition. The most important are Teak, Cedar, Sissoo, Blackwood, Cutch, Sandal Babal, Toon and Red Sanders (Fig. 69). Ironwood and Padouk are two useful timbers, not so well known as they deserve. Several trees have been introduced into India with success; amongst them may be mentioned Blue Gum, Feather-leaved Black Wattle, Broad-leaf Wattle and New South Wales Silky Oak, and Tallow Wood.

Forest fires and grazing have hindered the forestry work in British India. "The raiyats or peasants, and country people generally, have always claimed the right to graze their cattle, sheep and goats in forests and waste lands, and the necessity of regulating this practice in the case of browsing animals such as camels, goats, etc., which cause great destruction of shrubs and young trees, has been a great source of trouble. The number of live stock kept by the people is frequently far in excess of the supply of grass afforded by their holdings or the available waste lands, hence they have to fall back on the forests for food to keep them alive. As a rule, in the working of the reserves, while areas are strictly closed to grazing, either for the protection of young timber or for other reasons, at fixed times reasonable provision is made for

grazing, and it has come to be recognized that no rigid general rules can fairly be applied in view of the necessities of the large population, but that in regulating the privilege of depasturing stock, each district or forest must be dealt with separately as circumstances require. There have been cases in India, such as the Hushiarpur Chos, in the Punjab, where excessive grazing, especially of goats, has completely denuded tracts of hill slope, causing erosion of the soil and friable rock, and resulting in thousands of acres in the fertile valleys below being covered with detritus. A large extent of hill country in the Deccan, denuded and scarred by the rains, has been rendered barren from the same cause."

Australasia. In Australia, Tasmania and New Zealand there are 205,135,000 acres of forest land. "The true forest region of Australia is almost entirely coastal; that is to say, the most luxurious tree growth is confined to the mountain and hill ranges, which to a large extent follow, at a moderate distance, the bend of the coast, and to the tablelands and foothills which stretch from these towards the shore line. Where, however, the ranges approach closely to the ocean, as is the case with the Darling Hills in Western Australia, the forest belt may extend

beyond the watershed some distance inland, its limits being clearly marked by a greater rainfall and a more temperate climate. Thus, in Western Australia, the great belt of Jarrah, some 350 miles in length by 50 to 100 in breadth, which stretches eastward from the Darling Ranges, has two distinct but narrow belts of Tuart and Red Gum between it and the coast. Within the extensive tract of Jarrah, in the extreme south-western part of the colony, is the main Karri belt, stretching from Cape Hamelin to Torbay, and lying between 115° and 118° east longitude and 34° and 35° south latitude. This region, in which the Jarrah, Karri, Tuart and Red Gum are the dominant trees, has an annual rainfall varying from 35 to 40 inches. In the somewhat drier districts stretching eastwards of the Jarrah belt, there is a fairly wide strip of White Gum enclosing a narrower belt of York Gum, which, as regards its northern and southern limits, is almost coterminous with the Jarrah. Eastward of this again, and the arid region, where the annual rainfall is some fourteen inches and under, is entered, and the forest rapidly dwindles, changing first to a poorer growth of White Gum, until, in the sandy wastes of the gold-fields region, the vegetation changes to brushes, scrubs and dwarf trees, the latter being chiefly the Eucalypts,

locally known as Salmon, Morrell and Gimlet Gums, with some belts of Pine at intervals. Along the shores of the Great Australian Bight the vegetation is scanty and inferior, chiefly of stunted Eucalypts of the kinds last mentioned, Casuarinas, the Cyclopis Wattle and Grass Tree. It is not until the province of South Australia is entered that any elevated country is met with, and there the Flinders, Gawler and Mount Lofty Ranges are merely chains of hills of inconsiderable extent. In these ranges the timber consists of the Sugar Gum, the White Ironbark, two varieties of Stringy Bark, the White or Manna Gum, She Oak, and in the valleys and ravines Red Gum. It is, however, when the western part of Victoria is reached that the commencement of the great mountain system, as well as forest region, of Eastern Australia is seen. This extensive chain begins with the Grampians, a series of sandstone ridges running north and south, which rise sheer from the plains and culminate in the peak of Mount William, 3,827 feet above sea-level. Near this peak the spurs sink almost to the level of the plain, and, gradually swelling again into a ridge of low hills, rise to over 3,000 feet a few leagues to the eastward at Mount Cole, thence continuing across the colony in an easterly direction under the name of the great Dividing Range, and attain-

ing, in the Australian Alps towards the New South Wales border, elevations of 5,000 to over 6,000 feet. Following the trend of the coast the chain, now known as the Coast Range, runs northward through New South Wales, attaining, near the upper course of the River Murray, its highest elevation in Mounts Kosciusko and Townsend, 7,328 and 7,260 feet respectively. Thence it continues through Southern Queensland to the twenty-first parallel of south latitude, where it divides, one branch continuing northward to Torres Straits, while the other turns westward to the South Australian boundary, and forms the watershed between the streams which flow into the southern part of the Gulf of Carpentaria, and those which run southward into the River Darling. The forest region of Southern Victoria corresponds, to a considerable extent, with that of Tasmania, the principal Eucalypts being Blue Gum, Spotted Gum, Messmate, Stringy Bark, Silver-top Ironbark and Mountain Ash, with Evergreen Beech and Acacias such as the Black Wood and several species of Wattle. In the northern part of the colony the trees are of a kind common to New South Wales. Thus the best country bordering the River Murray and its southern tributaries is the home of the flooded variety of Red Gum, intermixed with Grey Box and (near the Murray) Cypress

220 TIMBERS AND THEIR USES

Pine, while the undulating land and low Silurian ridges between that river and the mountains are covered with two species of Ironbark, Stringy Bark and several kinds of Box. In New South Wales and Queensland, between the Dividing Range and the Pacific, are found some of the finest belts of forest on the Continent. Among Eucalypts are several varieties of Ironbark, Tallow Wood, Blackbutt, Grey Gum, Spotted Gum, Turpentine, Forest Red Gum and Red Mahogany; among conifers, the Moreton Bay, Brown and Bunya-bunya Pines; while among the brush timbers of fine grain are Red Cedar, Rosewood, Red Bean, Black Bean, Beech, Silky Oak, Beefwood and Tulip Wood. Westward of the ranges in New South Wales, where the tableland sinks down to undulating country and vast plains, through which the tributaries of the Murray make their way, the vegetation changes to scrub and open forests, consisting of Eucalypts such as Red Gum along the watercourses, with several varieties of Box, Cypress and other Pines and Wattles. Further inland again, the timber becomes more sparse, being chiefly Cypress Pine, stunted Eucalypts and Casuarinas, with extensive areas of Mallee Scrub. In Queensland a large portion of the country west of the Divide is an extensive plateau running into

great plains, well watered and covered with rich grasses, but with little timber. Towards the centre of the continent, where the land gradually falls to a vast shallow basin, with low hill ridges at intervals on its rim, and wide expanses of plain country with short water-courses losing themselves in the desert, the tree growth is very scanty, consisting chiefly of stunted Eucalypts such as the Gimlet Gum (*E. salubris* and *E. microtheca*), the desert She Oak, Acacias and Mallee. The annual rainfall in the coastal regions mentioned is in some parts exceedingly variable, ranging from 15 to 20 inches in South Australia, 20 to 40 inches in Victoria, 40 to 65 inches in New South Wales and 50 to 70 inches in Queensland. In the driest part of the central regions of the continent, a tract of country extending from 120° to 135° E. longitude and embracing a considerable portion of West and South Australia, the average fall is under five inches, many years being practically rainless, while in the belt surrounding this region it varies from 5 to 10 inches."

In New Zealand, the forest vegetation presents many distinct features from that of Australia, there being no Eucalypts, and the most valuable timber trees being conifers. Among these the trees which rank highest in commercial value are Kauri Pine, Otara, Rimu or Red Pine, Matai

or Black Pine, Kahikatea or White Pine, and the Westland and Silver Pines. Among other useful trees are four Beeches, the tooth-leaved, entire leaved, mountain and silver varieties; the Rata, a member of the Myrtle family; the Puriri or New Zealand Teak; the Black Maire (an Olive), the Hinau and the Tawa. The forests are fairly well distributed over the whole of the North Island, while in the Middle Island the most extensive belts follow the course of the alpine range which skirts the western coast.

The climate of New Zealand is mainly determined by its insular situation in the South Pacific, and as a whole the country is colder and more humid than Australia. Periods of lasting drought are scarcely known, and it is very seldom that a whole month passes in any part of the colony in the drier part of the year without rain. The usual annual rainfall, leaving out of account one or two places on the west coast of the Middle Island, where it is very heavy, varies from 35 to 50 inches.

This question of forest distribution is of course intimately associated with timber supply, but it is important from another point of view, that of climate, as our remarks have already shown to some extent. The question of the climatic influence of forests is so well and concisely summed up in the fourteenth report on forestry

in Victoria that we make no excuse for quoting that report at length.

"Few subjects," says the report, "have caused in our generation more difference of opinion among students of physical science than the question of the influence of forests on rainfall. On the side of those who maintain that this influence exists in a marked degree there is abundant historical evidence that in past centuries the destruction of forests in many of the countries bordering the Mediterranean, such as Palestine, Asia Minor, Greece, Dalmatia, Italy, Sicily, Spain and Northern Africa, was followed by marked changes in the climate, by periods of drought and flood, by the desiccation and erosion of the soil, accompanied by loss or diminution of fertility. It is not to be wondered at, therefore, that contemporary observers remarking these physical changes have, in chronicling them, attributed their occurrence to the removal of the tree growth, which it was early recognized played so important a part in modifying extremes of temperature, in binding the soil on slopes and hillsides and in regulating the flow of streams and springs.

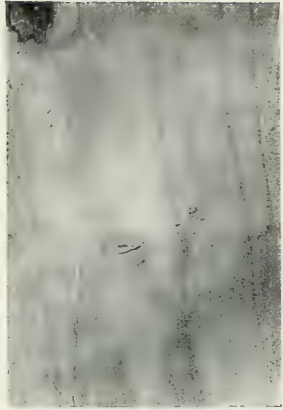
"Humboldt, when at the end of the eighteenth century he visited the Valley of Aragua, in Venezuela, remarked that the inhabitants were alarmed at the gradual diminution of the waters

of Lake Valencia. After comparing its condition with the descriptions of older writers, he became convinced that the area of its waters had very much diminished. Subsequently, he made a most careful examination of the circumstances, and came to the conclusion that the serious shrinkage was due to the extensive clearings of the surrounding forests which had been made during the previous half-century. In discussing the matter in his *Travels*, he makes this pregnant observation: 'In felling the trees which cover the tops and sides of mountains, men in every climate prepare two calamities for future generations—a want of wood and a scarcity of water.' Some twenty-five years afterwards, M. Boussingault visited the valley. The inhabitants informed him that not only had the shrinkage ceased, but that the lake had risen perceptibly. But in the meantime great political changes had occurred; wars had ravaged the country and greatly reduced the inhabitants, the tillage of the soil had been almost abandoned, and the tropical forest which so quickly reproduces itself on abandoned clearings had regained possession of the soil.

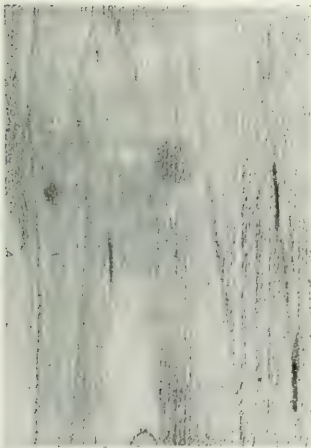
“ In the Island of Ascension, it is said, there was a fine spring, which was situated at the foot of a mountain originally covered with trees. The flow from this spring gradually shrank and



57. MAPLE.



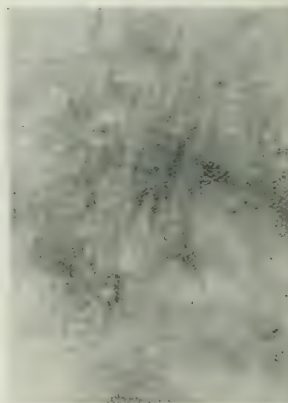
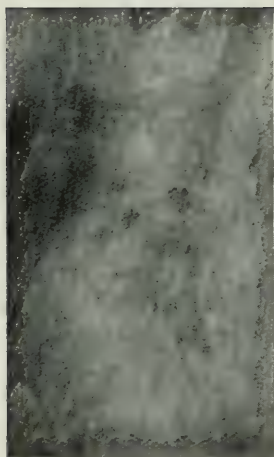
58. APPLE.



59. PLUM.



60. HORSE CHESTNUT.



61. BOX.

63. AUSTRALIAN NATIVE OLIVE.

62. LIGNUM VITÆ.

64. MUSK TREE.

dried up after the trees clothing the heights were felled.

“ When Dr. Hooker visited the island in 1843, there was only one tree on it and owing to the want of water scarcely enough vegetables could be grown for the commander’s table. In 1861, a large still for sea-water was erected, and progress was made in planting trees and shrubs, which had to be grown in nurseries and watered by hand. The mountain was gradually replanted, and in a few years the spring reappeared by degrees and soon regained its former abundant volume. In 1865 there were copses and thickets of some forty kinds of trees in addition to shrubs and fruit trees; the water supply was ample, while ships calling at the island, as well as the garrison, could depend on regular supplies of vegetables. The island of St. Helena was formerly covered with forest trees, but these were soon destroyed by woodcutters, while the ravages of goats stripped the shrubs and brushwood from the rocky heights. The denudation of the island was followed by serious droughts which caused great losses of live stock and crops. About the close of the eighteenth century great efforts were made to restore the vegetation, and as a result, it is stated, the climatic condition of the island was greatly improved.

“ In Mauritius, during the years 1842 to 1852,

some 70,000 acres of land were denuded. Several streams became greatly reduced in volume, while droughts, alternating with floods, frequently occurred. A local authority, writing in 1871, says that 'until recently the island was a mass of verdure. But,' he proceeds, 'when the forests were cleared to gain space for sugar cultivation, the rainfall diminished; the rivers dwindled down to muddy streams, the water became stagnant in cracks, crevices and natural hollows; while the equable temperature of the island entirely changed; drought was experienced in the midst of the ocean, the thunder showers were rarely any longer witnessed. The lagoons, marshes and swamps along the sea-board were no longer filled with water, but gave off noxious gases, while the river waters became impure from various refuse. After a violent inundation in February, 1865, fever of a low type set in.' This serious change in the climate led to replanting on a large scale, and after over a million trees had been restored the streams began again to reach their former volume.

"And now let us turn to recorded observations in India in our own day. Mr. Macartney, the agent of the Sandur State, Bellary district, in Madras Presidency, holds that during the last decade the rainfall in his district has become lighter and more irregular as the forests have

gradually been destroyed by woodcutters and charcoal burners, and the indiscriminate grazing of cattle, goats and sheep. His experience extends over twenty-two years, and on this point he says: 'In the first decade of my residence here, the tank near my house used to be regularly filled every year and to be running over for several weeks at a time. Latterly, though, it has accumulated an immense amount of silt, and is now, consequently, of diminished capacity; it rarely fills. The same remarks apply equally to the Remandrug tank, and to that of Singallkeni.'

"Major-General Fisher, R.E., an old resident of the same district, referring to the period 1856-64 states that when the hills were covered with jungle there was always a heavy cloud resting on them during the night and for the greater part of the day; rain, sometimes light and at other times heavy, fell at frequent intervals, and the average fall was found to be forty-five inches a year. The hill springs and small streams ran freely, and the water supply was most abundant during the whole of the hot weather. In the year 1864 he left the district, and did not return till 1879. In the interval the face of the country had changed; the jungle had been almost entirely destroyed, the annual rainfall was most precarious, and had fallen to

228 TIMBERS AND THEIR USES

under twenty-four inches; the tank had not been filled for three years, the springs were almost always dry, dribbling at the best, while the main feeder of the Darojee tank dried up by the end of February, and its tributaries had no water in them.

“ In the same way we might cite scores of instances recorded by observers in Pennsylvania, in New York, in the Upper Mississippi States, in New Hampshire, in Ontario and in South Africa, where the destruction of large areas of forest, especially in mountainous or upland regions, has been followed by diminished rainfall, and the shrinkage or drying up of streams and springs.

“ On the other hand, there is a school of inquirers, who, while admitting that forests serve a useful purpose in regulating the flow of streams and springs within their recesses, deny, or at any rate question, their power to materially affect the general climate of a country or its rainfall, holding that the latter is mainly determined by large expanses of sea and ocean, and by currents of air moving rapidly from one region to another. Thus, Oskar Peschel, while conceding that forests may have a local influence on precipitation of moisture says : ‘ The amount of rain depends on the extent of oceans and seas, on the degree of heat, and on the rapidity

with which the air moves over the surface of the waters. None of these conditions are changed by the extent or absence of forests. All air currents blowing from the sea are year by year charged with the same amount of moisture, which precipitates as soon as the air is cooled below the point of saturation. If such precipitation be caused by forests, the air currents reach the regions behind these forests drier and unable to yield a further supply of water.' But as Mr. Ribbentrop well points out, he does not take into account re-evaporation of moisture precipitated on the land, which, especially in hot climates, is very great from lakes and streams as well as from the soil and from the crowns of trees.

"But, without founding any general deduction on the recorded facts, we need not go beyond Victoria to find noteworthy instances of the difference of rainfall in fairly open or treeless districts and in thickly clad forest regions. The greatest precipitation in this state is in the Beech Forest, south of Colac, at an elevation of only 1,400 and 1,800 feet, the average annual fall being over 70 inches, while the maximum fall registered is 89 inches. But at the coastal stations surrounding this forest the highest records are only 42, 50.33 and 38.66 inches respectively.

230 TIMBERS AND THEIR USES

“On several parts of the Dividing Range, where the country is fairly open, the annual fall is from 30 to 35 inches; in other parts of the open, undulating or plain country of the northern areas, 20 to 25 inches; in other parts, 15 to 20; while in the wettest parts of Gippsland moderately close to the coast line, but chiefly in hilly forest-clad country, or settled country with a fair proportion of woodland, the average fall varies from 43·16 to 67·73 inches.

“With respect to the influence of forests in absorbing and gradually distributing rainfall, in preserving by their leaf cover and undergrowth the soil in a spongy and porous condition, so that the water precipitated in rain and snow is given out again in the form of small streams and springs, there is practically no difference of opinion. The contrast between the effects of a thunderstorm falling on bare hillsides, or in open country where the rainfall is quickly carried off to the lower levels in torrents and freshets, and the same storm discharging its rainfall over large expanses of tree-clad country, with the deep absorbent mould below protected from the direct action of the sun, is too plain to any observer to admit of dispute. And while the local evaporation is always greater in open country, it must not be overlooked that in addition to the heavy transpiration of moisture

through the leaves of trees, there is a steady though moderate evaporation from the surface of the forest-clad soil also, thus restoring to the air for future precipitation a portion of what had been absorbed in the form of rain.

“ Ebermayer in recording the result of observations made in Bavaria on this subject says: ‘ The forest alone, without the cover of dead leaves, diminishes the evaporation by 62 per cent as compared with that in the open. Evaporation is consequently 2·6 times less in the forest. A covering of dead leaves and vegetable mould diminishes evaporation by a further 22 per cent. Forests with an undisturbed covering of dead leaves and vegetable mould lessen the evaporation, as compared with that in the open, by 84 per cent.’ ”

CHAPTER VII

MANUFACTURES, ETC.

THERE are many manufactures in which wood is employed as the raw material; of these paper pulp is by far the most important. From time immemorial the fibres of various plants such as hemp, flax and jute have been used for the manufacture of paper. The Japanese make their paper from the bast of *Broussonetia papyrifera*, a Mulberry. The bast of this tree consists of a close network of fibres, these are hammered into sheets and the manufacture of paper of requisite evenness is complete. The use of wood as the basis of paper making is a comparatively recent introduction, and at the present time the timber supplies of certain parts of the world are being seriously drained to supply the demand.

Nearly all the timber used in the manufacture of "chemical" wood pulp is derived from Canada and Scandinavia, and the timber used is mainly Pine and Fir. In America and on the Continent non-coniferous wood, such as Poplar, (Fig. 13), is used in largely increasing quantities.

The conifers yield more cellulose or pulp than other wood and their fibres are larger than are those of deciduous trees.

Wood pulp may be either mechanical or chemical. Mechanical wood pulp, as its name implies, is manufactured by mechanical means alone, no chemicals taking part in the process. It is used for making the cheaper grades of paper only, and although the idea of making paper by mechanical means alone is an old one, it is only by the aid of modern machinery that the idea has been developed. From Messrs. Cross and Bevan's excellent textbook of paper making, which should be consulted by everyone interested in this important manufacture, we quote the following details of the process.

“The wood is first cut up into blocks, the size of which is determined by the width of the stones used for grinding; any knots present are cut out with an axe. The stones are made of sandstone, and are covered over three quadrants with an iron casing, the remaining quadrant being exposed. The surfaces of the stones are made rough by the pressure of a steel roll studded with points which is pressed against the stone while revolving. In addition to this, channels about $\frac{1}{4}$ inch deep are cut into the stone at distances of 2 to 3 inches. They are made in two sets, crossing each other in the centre

of the stone, and serve to carry off the pulp to the sides of the stone, in addition to giving increased grinding surface. The presence of the blocks of wood against the stones is steadily maintained by screws worked by suitable gearing; this is necessary in order to obtain a pulp of uniform character. A stream of water is kept constantly playing on the stone; by this means the pulp, as fast as it is formed, can be conveniently carried away. It is first pressed through a rake, which retains small pieces of wood that have escaped grinding. The stream of pulp then passes through the sorters, the object of which is to keep back such portions of the wood that have not been sufficiently disintegrated. These consist of cylinders about three feet long and two feet in diameter, covered with a coarse wire-cloth. The fibres that are retained by this wire, fall into the refiners, which consist of a couple of horizontal cylinders of sandstone, the upper one only of which revolves. Here they are further disintegrated, and are again passed through the wire-cloth; this is repeated until all the fibres have passed through. The pulp, after passing through the first sorter, may be conducted through a series of gradually increasing fineness, and, by this means, be separated into different qualities. Though pulp so prepared cannot compare with chemically

prepared stuff, as the fibres are extremely short and have comparatively little felting-power, it may be used with advantage as a sort of filling material.

“ In some grinding machines the stones are mounted horizontally on vertical shafts, but in modern installations the preference appears to be given to the vertical type of stone, mounted on a horizontal shaft. Wood grinders are constructed for both steam and water power in units often exceeding 1,000 h.p., but in the vast majority of cases the site of the mill is selected where water power is plentiful and the grinders are driven directly from the turbines.

“ Two kinds of mechanical wood pulp can be prepared, according as the wood is found across the grain or in the direction of the grain. The cross-grain fibres are shorter and more mutilated than the long-grain fibres, but the latter do not give so fine a pulp, and the process of long-grain grinding is very seldom used.

“ The quality of mechanical pulp varies within very wide limits according to the texture of the wood (age and seasoning), and the texture and sharpness of the grinding ridges of the stone. The quality of pulp suitable for making heavy boards is quite different from that suitable for printing papers. The effect of variable conditions of grinding or the quality and produc-

tion of the pulp has been studied by Clive and Thickens, who state that under similar conditions the strength of the pulp increases with the power expended per ton in the grinding. The qualities of mechanical pulp, unlike those of the cellulose fibres, cannot be modified subsequently in the beating process, so that the paper making is entirely dependent on the conditions adopted in grinding.

“At the present time the main varieties of mechanical wood pulp are prepared, viz. ‘cold-ground’ and ‘hot-ground.’ Cold grinding is effected under moderate pressures between wood and stone, the pulp being washed away by copious streams of water. In hot grinding the pressure of the wood against the stone is extremely high and the stream of water reduced to a minimum, so that a very high temperature is developed at the surface of contact. Hot grinding is more economical than cold grinding, and is stated to yield a finer and larger pulp than cold grinding, but cold-ground pulp possesses a quality known to the paper maker as ‘wetness’ or hydration in a high degree.

“A distinct variety of mechanical pulp is manufactured from logs which have been thoroughly softened by steaming in digestors under pressure. This is known as ‘brown mechanical’ or ‘leather-board’ pulp. The

steaming process is a complex attack of the lignone components of the wood with reactions of hydrolysis, oxidation and condensation, the effect on the wood being a loosening of the fibres, and incipient breakdown, as a result of which the action of the stones is attended with less disintegration than in the case of raw wood. At the same time, portions of actual encrusting matters are gelatinized and converted into a colloidal condition, and this, in association with the greater length of fibre, imparts extraordinary toughness and strength to the boards, etc., made from brown mechanical pulp. The reactions of oxidation and condensation under treatment with steam produce brown colouring matters, which cannot be effectively removed, so that the application of this pulp is restricted to the manufacture of 'leather boards' and brown wrapping papers. In a modification of the process, the wood is alternately boiled with water and steamed under pressure, whereby a pulp of better quality and paler colour is produced.

"Mechanical pulp whether 'white' or 'brown' is in many cases worked up into finished boards at the mill. If the pulp is required for shipment or transport it is made up roughly into thick sheets by means of a board machine. . . . Obtained in this form the pulp is readily transported, and comes on the market almost invari-

ably in the moist condition, containing fifty per cent of air-dry pulp. It may be mentioned that this practice is not a matter of mere convention. It involves an obvious and serious addition to freight and transport charges and some risk of attack by moulds and micro-organisms. It is based upon the retention of paper-making quality by the pulp, which is injuriously affected not only by drying, but in the process of repulping with water.

“The woods commonly employed are White Pine, Spruce and Aspen. The last named yields a finer pulp of a better colour, but of inferior strength.

“Paper containing mechanical wood pulp is very liable to become discoloured by the action of air and light, the ligno-celluloses being much more readily acted upon than the celluloses isolated from them. Such fibre is, moreover, of low felting quality, it has, in fact, little to recommend it but its comparative cheapness. It is nevertheless used in large quantities, some cheap papers being made almost entirely from it.”

In the manufacture of chemical wood pulp the mechanical processes are reduced to a minimum, and the pulp is extracted almost solely by chemical means. It is hardly necessary or advisable to enter into a discussion of

the various chemical reactions which take place during manufacture, a brief outline of the methods employed will suffice for our purpose. Again we repeat that full and lucid details may be found in Messrs. Cross and Bevan's work from which our information is derived.

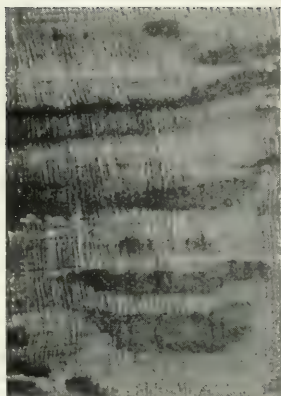
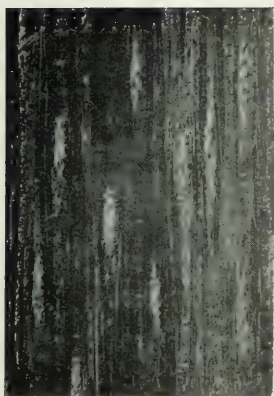
There are two leading methods of obtaining wood pulp by chemical means, the alkaline process and the bisulphite process. In the former process wood of inferior quality may be used, for the action of the chemicals employed is so powerful that rotten wood, knots, etc., are all attacked. In the latter process, on the other hand, carefully selected raw material is essential, containing little resin and uniform in colour and structure.

In the alkaline process the bark is stripped from the timber and the wood chipped and passed through a mechanical "duster" to the boiler or digester. The boilers are either of the horizontal cylindrical or spherical rotary types. Upon the wood is poured a lye, consisting of 6 to 8 per cent caustic soda; the boiler is then closed and heating is rapidly taken to a maximum steam pressure and so maintained for 8 to 10 hours. "The resulting pulp is washed by the process of economic lixiviation in successive tanks, and is obtained of a brownish grey colour.

The dark brown lye is treated for the recovery of the soda by the process of evaporating and calcining."

A process which, in Europe, has almost entirely superseded the above, consists in using a lye consisting of three parts of caustic soda to one part of sulphate of soda. It is used mainly for obtaining chemical pulp from conifers. "A direct function of the sodium sulphate may be to limit the hydration of the cellulose of the fibre under the attack of the caustic alkali at the high temperatures necessary for the resolution of the ligno-cellulose; and this secondary effect of the process favourably affects the yield of cellulose which is about 10 per cent more than that obtained with caustic soda alone; moreover the fibre is in a better state of preservation and of superior quality." An unpleasant part of the process is the evolution of evil-smelling gases; useful by-products, however, are obtained, and "the recovery of methyl alcohol, oil of turpentine and an inferior grade of resin, suitable for the sizing of brown papers, is practised on a commercial scale."

"Soda or sulphate pulp is characterized by the dull brownish shade in the unbleached condition"; it requires considerably more bleaching powder than sulphite pulp for the production of a fair white colour, but the brilliancy obtain-



65. GROU' GROU.

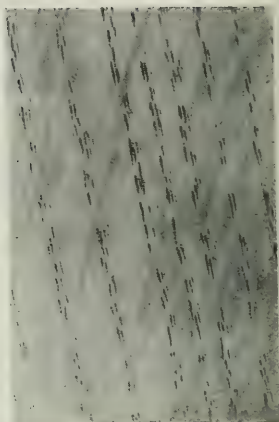
67. TALLOW WOOD.

66. AUSTRALIAN NATIVE SYCAMORE.

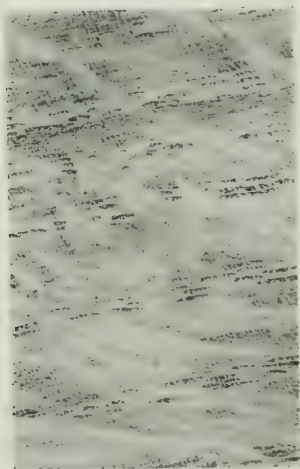
68. AUSTRALIAN ROSEWOOD.



69. RED SANDERS.



70. ENGLISH OAK.



71. ENGLISH OAK.



72. ENGLISH OAK.

able is never equal to that produced with bleached sulphite pulp.

All commercial wood pulps, both sulphate and sulphite pulps, are produced in various grades, classified broadly as "bleaching" and "strong" pulps. The variations correspond to differences in the degree of digestion as determined by the strength of the boiling lye and the temperature and time of treatment. A fully digested "easy bleaching" soda pulp will consume from 15 to 18 per cent of bleaching powder, and will lose from 8 to 10 per cent in the process of bleaching.

"Strong" soda pulps are darker brown in colour and cannot be bleached economically, whilst the extra strong or "kraft" varieties are suitable only for brown wrapping paper.

The introduction and development of the sulphite process marks an epoch in paper making. It has added "to the paper makers' supplies celluloses of different characteristics from the 'rag' celluloses, chemically inferior, but structurally offering certain advantages in regard to the production of cheap papers."

The chemicals employed in this process are sulphate and bisulphite of lime, bisulphite of magnesia and free sulphurous acid. The wood must be so prepared that the lye can quickly and completely penetrate its tissues. This is

brought about by removing the bark entirely and taking out all knots. The wood is first chipped, then disintegrated between crushing rollers, all unsound parts are taken away, and the rest transferred to the digesters.

The digesters are lined with some substance which is not affected by the free acid, usually some kind of cement, i.e. a mixture of Portland cement and silicate of soda. The period of digestion varies from 16 to 20 hours under a pressure of 75 lbs. per square inch to 70 to 80 hours under a pressure of 45 lbs. per square inch.

“The products are the pulp, or fibre, and the waste liquor containing the sulphonated lignone bisulphite compounds. Careful mechanical purification of the digested material, washing, separation of the fibres from imperfectly digested chips, small knots and dirt by a system of traps and strainers, are necessary before the pulp is run off into webs or sheets on a presse-pâte or simple form of paper machine.”

There are two main groups of wood cellulose; those obtained from deciduous trees such as the Poplar, and those derived from conifers, the latter being the more frequently used in paper making. “The chief commercial varieties are Aspen and American Poplar, prepared mostly by the soda process, but also to some extent by

the sulphite process." Other varieties which come on the market in smaller quantities are Birch, Red Beech and American Chestnut. "For soft absorbent papers, such as blottings and copper plate printings, Poplar and Aspen are employed to a considerable extent as excellent substitutes for the soft cotton rags generally used in the more expensive grades."

The method of preparation is used as a basis for the classification of the coniferous wood celluloses; they may be soda or sulphite pulps, and these again are divided into "strong" or low-boiled and "easy bleaching" or high-boiled types.

The practically transparent grease-proof and imitation parchment papers are prepared by "beating 'strong' wood pulps between very broad, blunt knives for about twelve hours, with the object of crushing and shredding the fibres rather than cutting them, thereby forcing the water into combination with the cellulose, so that the latter is gradually reduced to a gelatinous mass. It may be assumed that if any considerable degree of strength and elasticity is to be retained in the paper, care must be taken to avoid the 'dead' beating of the fibres during this very severe treatment, and that the length of the fibres should be maintained as far as possible, although in such extreme cases a certain

proportion of non-felting fragments of cellulose cannot be avoided. It may be assumed that the ideal condition of a hydrated pulp, whatever may be the degree to which hydration is carried, is one in which the fibres, almost unreduced in length, are each surrounded by a gelatinized envelope of their own cell substance, gradually merging towards the interior into unmodified cellulose. In other words, the cementing substance, which is the valuable product of hydration, should be self-contained on the outside of each individual fibre."

Wood Distillation. A considerable amount of wood is, especially on the Continent, subjected to dry distillation, that is to say heating for several hours at a temperature of 600° F., for the sake of the valuable distillates and residues obtained. The distillates consist of water, crude pyroligneous acid, wood spirit and gases and the residues of charcoal and tar. On the Continent gas, approximating to coal gas, is obtained by the destructive distillation of wood; it consists of hydrogen, carbon monoxide and various hydrocarbons. Pyroligneous acid is subjected to redistillation and yields acetic acid, and, after further treatment, vinegar. It is also used in the preparation of acetate of lime on a large scale with naphtha from which, after treatment

with lime and redistillation, wood spirit or methyl alcohol is obtained. Tar obtained by the distillation of wood contains acetic acid, pitch and tar oils. By neutralizing the last named with carbonate of soda, and redistilling, creosote and paraffin are obtained.

Charcoal Making. Closely allied to the distillation of wood is the old industry of charcoal making, popularly but erroneously called charcoal burning. Charcoal, as we have mentioned, is one of the products of wood distillation, but usually the charcoal maker takes no thought of the by-products.

In this country charcoal making is, or was till recently, almost as extinct as the Dodo. In one or two counties in the South and in the North it existed in a moribund condition.

The wood for making charcoal is cut into pieces two feet long or thereabouts, and usually only small faggots less than two inches in diameter are used.

Mr. Webster gives the following account of the construction of a charcoal pit: "A strong stake is driven firmly into the ground and left protruding about a foot. Around this are placed small pieces of dry Ash of equal length, and standing as close to the upright stake as possible; around this ring another layer is placed in the

same manner, and this process is continued until a circle five feet in diameter is obtained. A circle one foot in diameter, and having the top of the stake first driven into the ground as centre, is next made by placing the wood horizontally on the upright pieces, and side by side, the end of each piece being placed at the circumference of the circle already made and directed towards the centre. Layer upon layer is built in this manner until the pit is of the required height, the wood used here being dry pieces of Ash two feet in length, but split rather smaller than the ordinary pieces. A sort of chimney is thus formed, by means of which the pit is fired. Outside the core the wood is placed on end and reclining inwards, this being continued until the pits are of the required size. When the building is completed the pits are covered with newly cut turf, the grassy side innermost, beginning at the base and working towards the top, each line of turf overlapping the previous one by a few inches. The circular hole or chimney is left open for firing. Before turfing the top half of each pit it is carefully examined, and any crevices between the wood packed full of small pieces of turf and sawdust to exclude air. The turfs are cut about one foot in width and of any convenient length.

The quantity of turf required for two pits of the dimensions stated is seven loads.

“When the pit is satisfactorily covered, it is fired by dropping a couple of shovelfuls of burning wood and some dry pieces of Pine and Ash into the opening left at the top; the top turf is then put on, which effectually shuts up the chimney, and the process of charring commences.”

Smoke issues from the whole pit. In fair, calm weather little further attention is required, but, in windy weather, the wind causes the wood, at the side where it strikes, to burn rapidly, and the side of the pit to fall in; when this happens, the cavity formed must be at once filled with more wood and returfed.

The best charcoal is made in slow-burning pits; seven days or so are required for the wood to be completely charred in pits of the size mentioned, smaller pits require less time. “When the pits have burned out and become cool, it is found that they are reduced to rather less than half their original size.”

For the most part thinnings from the previous season are used for making charcoal. “The proportion of wood to charcoal varies greatly, much depending on the size, quality and maturity of the timber. . . . From about the twelfth century onwards, Scotland, where wood was abundant,

produced annually a large quantity of charcoal iron; and in 1660 the Navy Commissioners nominated John Evelyn to investigate the denudation of forests, owing to the manufacture of charcoal for iron smelting, and the following quaint extract from his report will be interesting: 'Nature has thought fit to produce this wasting ore more plentifully in woodlands than any other point, and to enrich our forests to their own destruction—a deep execration of iron mills and iron masters also.' The Lorne works, in Argyllshire, were started in 1753 and annually consumed upwards of 3,000 tons of lump charcoal."

Tanning. Various barks are used in tanning, and in this country at any rate, the Oak is the main source of supply for tanning bark. The question of bark stripping versus tree felling is an important one. The quality of most, if not all, trees is affected by the season at which felling takes place and this is especially the case with Oak. Timber felled in the winter when there is the least sap in the tree is, other things being equal, superior to that felled in the spring. On the other hand, spring is the season when the bark contains the most tannin and is therefore of the greater value for tanning; moreover, the bark is more easily stripped in the spring.

At the time the leaf buds are bursting is the best for peeling the bark, and the whole of the work should be completed before the trees are in full leaf. After the trees have been felled the stems are usually stripped of bark on the spot, the strips being cut in lengths of about a yard. On the completion of stripping the bark is seasoned in specially prepared stacks, where it is sheltered from the rain, but exposed to the wind. Seasoning should be completed as speedily as possible and with little disturbance of the bark, for constant turning reduces its value. When the bark is in such a condition that it breaks easily instead of bending, as it will when fresh, it is sufficiently seasoned for the purpose to which it is to be put.

Fuel. The use of wood as fuel may not, at a cursory glance, appear to be of sufficient importance to warrant any mention. As a matter of fact the subject is one that is invariably neglected by the householder, and almost as frequently by the dealer. Wood, according to its treatment, may contain anything from about 2 per cent to 8 per cent or more of moisture. Kiln-dried wood is, or may be, practically wanting in moisture, whereas green wood is often so full of moisture that its presence is obvious. As an intermediate stage may be

250 TIMBERS AND THEIR USES

mentioned wood which has been stacked for some time, less moist than green wood, but more so than kiln-dried wood. It is clear that firewood, to be really efficient, should be seasoned. "Every pound of water combined in the wood requires about 600 units of heat to evaporate it, the unit being the amount of heat necessary to raise 1 lb. of water 1° C.; so that 100 lbs. of wood with 25 per cent moisture only furnishes about 255,000 units, whilst if kiln-dry, with 2 per cent moisture, it would yield 350,000."

Of our native fuel woods none can compare with Beech, Oak and Ash for heat-giving qualities and general utility. Hawthorn, Apple, Yew and Pear are also valuable in this connection; Hazel too is useful, but difficult to obtain in quantity. Elm is a slow burner, the conifers on account of their resin burn quickly and brightly. Birch is also a rapid-burning wood, but emits comparatively little heat. Plane, Willow, Poplar and Sycamore are also in more or less request for fuel, but all of them should be properly seasoned to yield satisfactory results; in fact the only British wood which will burn at all well when green is Ash. The older the wood, the longer it will last and the greater heat it will emit. Though it is hardly likely that timber of the best quality would be used for burning, care should be taken to avoid decayed or dis-

eased timber, and in all cases the heartwood provides better fuel than the sapwood.

Finishing Wood. An enormous amount of timber is used the world over for interior decoration of houses, railway carriages, passenger steamers, etc. Wood for this purpose should be of the highest quality and free from resin pockets, knots, etc. It should be carefully milled and left free from tool marks of any description; a further dressing with a hand-smoothing plane and fine sandpaper will improve its appearance, or a steel scraper may be used in place of the plane. The sandpaper must be fine and must be worked in the direction of the grain. Timber for finishing should be absolutely dry. "Beautiful and permanent effects cannot be secured if the material used is not dry. Paint or varnish will not cling to moist wood." Where coniferous woods are being used, efficient drying is doubly essential or gum and moisture may ooze through the finish in small bubbles.

Various finishes may be applied to the timber, and it is hardly necessary to detail them here. For satisfactory work timbers with ornamental grain and figuring should be selected. Natural finish is simple and tasteful for certain wood, especially some of the conifers; oil stains bring

out the grain in a remarkable manner and improve the tones of the wood.

Basket Making. The growing of Osiers, *Salix viminalis* and *S. triandra*, for basket making is now largely a French industry, at any rate in that country the best osiers are grown. The rods should be straight and so pliant that they may be readily bent without breaking. The Osiers are cut before the leaves open and at a time when there is no frost. After cutting the rods are dried and then tied up in bundles according to size. If they are tied in the wet state they become brittle and useless.

“ For the past few years the demand in this country for high-grade Willows has been greatly in excess of the supply, in fact, hardly one-fifth of our requirements are produced at home. Germany, three years ago, exported Willows and rods to the value of £40,000, representing an increase in five years of fully one-half; while of the manufactured articles in the way of caskets and basket ware the total value of her exports exceeded £42,000. As giving some idea of our wants in this direction it may be stated that the total value of Willow rods annually sent to this country from the Continent is in round figures about £100,000, and of baskets and basket ware fully £170,000. What a con-

trast to the state of affairs at that period in our history when an important export trade was done in Willows by this country !

“The Willow-working industry is a rapidly expanding one, and, owing to the increasing demand, the value of peeled Willows is gradually on the increase, present prices ranging from £24 to £38 per ton for those of best size and quality. These are in the main exported and used for high-class work in the basket trade ; rougher unpeeled Willows, that are largely in use for cheap packing hampers and farm purposes, bringing in a much lower price. Fruit baskets in immense numbers are annually imported from the Continent, one firm alone having sent over 150,000 ; while at the Leith basket works, which mainly cater for the agricultural and fishing industries, thousands of herring baskets alone are sent out every month, and the packing-hamper department is of great interest and a special feature of this enterprising firm.”

CORK is the outer bark of the Cork Oak, *Quercus suber*, a native of Southern Europe and Northern Africa. Like a vast number of other plants, the outer or exposed parts of this Oak are covered with cork, but in this tree alone is the bark found in masses sufficiently large as to be worth the trouble and expense of cutting.

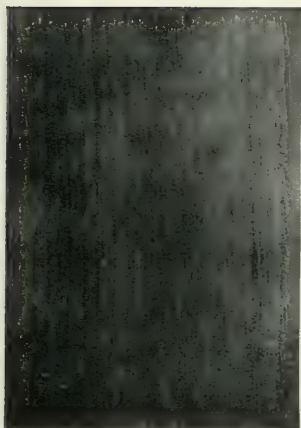
Cork is a valuable economic commodity because of its imperviousness to moisture, its elasticity and firmness. Mr. Leroy Sargent gives the following interesting account of the uses, growth and harvesting of cork: "In the young tree the first few layers of cork are comparatively thick, while those formed later are only about 1 to 2 m.m. in thickness and soon become so brittle and so badly cracked as to be unfit for finer uses. Such inferior cork, suitable only for fuel, packing, fish-net floats, rustic work in conservatories and the like, is all the tree ever produces if left undisturbed. But in cultivation, when the trees are from fifteen to twenty years old, all of this 'virgin cork,' as it is called, is cut away, great care being taken not to injure the tender part within, known as the 'cork mother,' because it includes the cambium. The effect of this operation upon the tree is in every way beneficial. Henceforth the cork produced is more abundant, softer and more homogeneous; the breathing channels are farther apart; and the cracks become far less troublesome. For a century and a half, or even longer, at intervals of eight to fifteen years, slabs of fine cork 5 to 20 c.m. thick are peeled from the trunk. The harvesting takes place in summer when the inner bark adheres most firmly to the wood. After being stripped from

the tree the slabs of cork are scraped so as to clean the outer surface, are then flattened under pressure with the aid of heat, and finally tied in bundles for shipment.

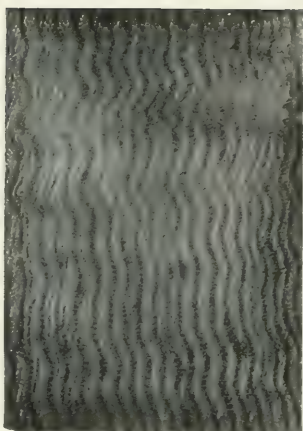
“By far the most important use of cork is for stoppers. It is estimated that the daily consumption amounts to twenty millions. Cork stoppers are cut either by hand or by machinery. Large flat corks have to be cut so that the channels pass from top to bottom. Such corks require, therefore, the use of some sealing material such as wax, to make them impervious. Smaller corks are cut so that the channels go from side to side and hence are airtight without sealing. In the cutting, almost half the material, or more, becomes waste chips. So valuable are the properties of cork, however, that even in this form it may be utilized in important ways. Thus, pulverized and mixed with rubber or with boiled linseed oil, it forms, when spread on canvas, a floor covering at once durable and sound-deadening. Coarsely ground cork serves well on account of its softness and elasticity as packing for fruit, especially grapes; and, when glued to paper, forms a safe wrapping for bottles in transportation. The same remarkable properties make masses of cork most effective buffers for vessels. In the form of thin sheets it has long been used as a material for insoles

and hat linings. The lightness of cork has especially recommended it for artificial limbs, handles, net floats and life preservers; while the uniform texture and the ease with which it may be shaped have made it valuable to model makers and even to turners and carvers.

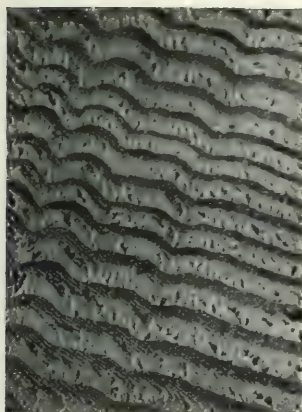
“Although cork was known to the ancient Greeks and Romans, and there is record of its use by them for the soles of shoes and as stoppers for wine vessels, it has been generally used only within the last few hundred years.”



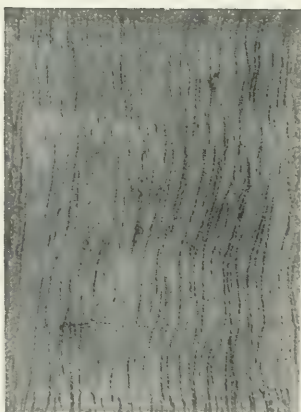
73. KAYA S.P.



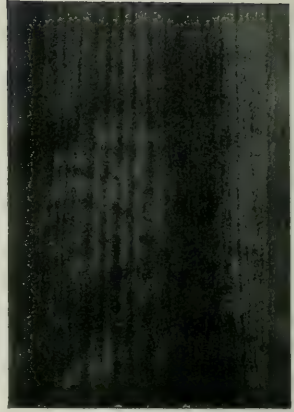
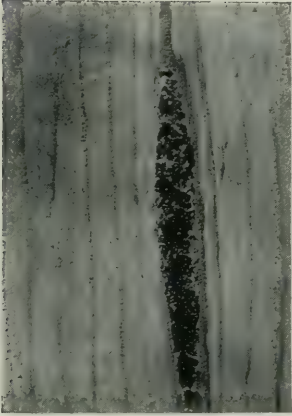
74. WAVY GRAIN T.S.



75. WAVY GRAIN T.S.



76. SINOUS GRAIN I.S.



77. A "GUM POCKET."

78. RESIN DUCT IN CYPRESS.

79. RESIN DUCT IN
MAHOGANY.

80. A COMMON DEFECT OF
MAPLE.

CHAPTER VIII

THE STRUCTURE AND FORMATION OF WOOD

WE, in these pages, are not concerned with the botanical characteristics of trees in general, the essentially botanical characteristics that is, such as the flowers and fruit, the leaves and leaf modifications. In order that we have a thorough understanding of the nature of timber, however, it is necessary to know something of the nature of wood, how it arises, grows, is nourished and its form when growth is complete.

Let us be clear, in the first place, exactly where we may expect to find wood. In our pages we often use the word wood when we refer to timber, and it is commonly so used, but wood may be found in many other plants besides trees. In fact it occurs in the majority of plant stems higher in the scale of development than the ferns or vascular cryptogams. The stem of an old Wallflower or even of a Cabbage may become woody, but in such an event the wood, it need hardly be added, is useless for timber. In order that the wood of

any plant may be classed as timber it must be present in greater quantity; it is hard to give an exact definition of a timber tree, but the Hazel may be taken as approximately the minimum size of a timber-bearing tree.

The function of wood is mainly a mechanical one—it acts as a support to the growing stem, holds the branches in position and, except in rare cases, keeps the plant in an erect position.

All the flowering plants are or with age may become woody—such flowering plants are known as *Phanerogams*. The *Phanerogams* again are divided into two great groups or divisions; the *Gymnosperms*, or plants with naked seeds, and the *Angiosperms*, or plants with covered seeds. The latter are further divided into two classes, the *Monocotyledons*, plants with a single seed leaf or cotyledon and *Dicotyledons*, plants with two seed leaves or cotyledons. Of the *Gymnosperms*, trees of the Natural Order *Coniferæ* are also useful for timber. All the members of this order bear cones, which in reality are overlapping scales on which the seeds are borne. Their leaves, with the exception of those of the Maidenhair Tree, are needle-like, their wood is soft and resinous. There are exceptions to this rule, however, for the Yew and Maidenhair Tree do not have cones, and the former is not resinous;

again, many other trees besides the conifers are known as softwoods.

Of the *Angiosperms*, the *Dicotyledons* alone need be considered from a timber-bearing point of view. They bear broad leaves, for the most part and, like the *Gymnosperms*, their stems increase in thickness owing to successive annual growths of wood. These yearly additions of wood are clearly seen as rings, known by the name of annual rings (Fig. 81), in any cross section of a dicotyledonous tree.

We may mention here, as we shall explain later, that these rings may be formed other than annually under exceptional circumstances. There is good reason for the continued growth of the dicotyledonous stem as compared with the almost stationary (as far as girth is concerned) monocotyledonous stem. We have stated that the wood supports the stem, but it does more. Through the tissues of the wood, water and dissolved raw food material taken up by the roots passes to the leaves, then to be elaborated and converted into complex substances such as starch and sugar, which serve to nourish the tree and to feed the growing points. The greater part of the moisture which finds its way to the leaves is given off, in the form of vapour, into the air. The stem also acts as a store-house, much of the manufactured food being

held in reserve in the cells of the medullary rays.

Let us, for the sake of greater clearness, examine a stem in its early stages of development, and trace the changes which take place as the stem becomes older. The initial stages of growth may best be studied at the growing point of the stem, and the growing point is situated in each bud with which the stem or its branches terminate.

At the extreme tip of the stem we find a tissue, i.e. a collection of cells, amongst which there is little or no differentiation; one cell is almost exactly like its neighbour. Under the microscope a section of the growing point appears to be composed of a delicate honeycomb. The simile is hardly apt, as we shall see when we have studied these plant tissues more closely, but their discoverer, more than two hundred and fifty years ago, likened them to the comb of the honey bee and called them cells, a name by which they have been known to the present day. These delicate cells are all bounded by cell walls composed of cellulose, a substance composed of carbon, hydrogen and oxygen and known as a carbohydrate. Cotton wool is almost pure cellulose. Each of these cells contains a substance known as protoplasm which is composed of carbon, hydrogen, oxygen, nitrogen, sulphur,

phosphorus, and other elements in minute proportions.

We have already mentioned that the cells at the growing point are to all intents precisely similar to one another, that is to say they exhibit no differentiation; as we pass from the growing point to the older parts of the stem we cannot fail to observe that there is a differentiation of the cells and that there are several groups of cells or tissues, totally unlike one another in structure, but all designed to serve some special purpose.

How are these tissues formed? They arise from meristematic tissue, that is to say tissue whose cells are capable of division to form new cells. The first signs of this meristem appear very near the growing point, in fact almost at that point it is possible to distinguish three distinct kinds of tissue, and this tissue has been formed by the meristem of the growing point. Let us try to make the point a little clearer. The cells of the growing point, which so closely resemble one another, are not permanent; they constantly divide, by means of a wall which is formed across each one. As a consequence new tissue is formed continuously, and this new tissue differs from the tissue from which it was formed by the fact that all its cells are not alike. There is a central core of tissue, just

behind the growing point, easily recognized by the fact that its cells are elongated. This core is known as the *plerome*, and by tracing it backwards to still older parts of the stem we shall see that it forms the vascular system (wood and blast).

Surrounding the *plerome*, and distinguished by its cells being divided both parallel and at right angles to the exterior of the stem, is the *periblem*, a tissue which gives rise to the cortex. Outside the stem there is a single layer of cells, with transverse walls which are thickened on the exterior. This tissue is the dermatogen and gives rise to the epidermis of the plant. It is clear, therefore, that from the meristem of the growing point tissues arise which become, epidermis, cortex and vascular system. There are other meristematic or dividing cells, but they do not occur in the very young parts of the plant and we shall treat of them later.

Let us now take a cross section through a stem a little way behind the growing point, but not so far that all the tissues are fully developed. Our section, if we have made it at the right place, will show us a large number of very thin-walled, comparatively big cells, surrounded by a ring of almost egg-shaped groups of cells so arranged that their more pointed ends are directed towards the centre

of the stem. In *Monocotyledons* the structure is different, but we are not concerned with them. On the outside is a single layer of cells, with thickened outer walls. The central cells are the pith, the ring of groups of tissue is the procambium lying in the cortex, and the outer layer of cells is the epidermis. The pith occupies a considerable area in the cross section of a young plant, but, in the case of timber trees at any rate, it either occupies so small a space in the older parts as to be negligible or its cells die or decay away leaving the centre of the stem hollow.

The procambium is a meristematic tissue, that is to say, as we have explained above, a tissue capable of forming new cells by division. It has, moreover, the important property of forming two totally different kinds of tissue. On its inner side it forms wood or xylem, on its outer side it forms bast or phloem. Between these two tissues the meristematic tissue remains and is now called fascicular cambium.

The structure of the stem now in a still older part, where the bundles of wood and bast are just beginning to be formed, shows these essential tissues. A central pith; a ring of vascular bundles, each consisting of inner wood, central fascicular cambium and outer bast; a tissue called cortex, external to the ring of bundles,

and an outer epidermis. Between the bundles there is tissue connecting the pith with the cortex, and known as the primary medullary or pith rays.

Taking a still older part of the same plant, and making a cross section, it is obvious that certain changes have occurred. We can still distinguish the pith, the ring of bundles, the primary medullary rays, the cortex and the epidermis. In addition careful observation will show that each bundle is connected to its neighbour by a layer of minute cells which have passed right across the primary medullary rays. As a result the bundles appear to be suspended on a complete ring of tissue; this tissue is the cambium, the meristematic tissue which forms wood inwardly and bast outwardly. The cambium within the bundles is still known as fascicular cambium, while that which connects neighbouring bundles is called interfascicular cambium. When a young stem is peeled, it is along the ring of cambium that the peeling takes place, and the gummy substance with which the exposed surfaces are covered is the protoplasm contained in the cambium cells. Sometimes, though wrongly, the whole of the tissues lying outside the cambium ring are called the bark; we shall show later why this is incorrect.

Once more making a cross section through a still older part of the stem, we shall see that great changes have taken place as growth has proceeded. The central pith has not increased in area, it may even have decayed away entirely; the cambium has actively formed wood within and bast without, with the result that we are presented with a solid, broad ring of wood; a ring of thin-walled cambium cells; a ring of bast, which is smaller in area than the ring of wood; a ring of cortex surrounded by cork cells which, with the epidermis, form the true bark and are formed from yet another meristematic tissue. Running from pith to cortex are a number of radial lines of tissue, the primary medullary rays (Fig. 72), and a number of smaller, finer lines which do not extend the whole of the way from pith to cortex, the secondary medullary rays (Fig. 72). The wood is marked with a number of concentric rings, annual rings (Fig. 72), which represent approximately the number of years of growth of the tree.

Now we must turn our attention to the structure of the various tissues to be found in the stem. We cannot do more than give an outline of the more essential points, but the reader who would learn more of plant structure will find all he requires in one of the many

excellent textbooks of botany which are published in this country.

We have said that the function of the central portion of the ordinary plant stem is two-fold. Its mechanical function is to support the stem. Its physiological function is to form a channel for the transport of raw food material from root to leaf, and of elaborated food material from leaf to growing points, storage organs, etc. We should expect to find, therefore, that the tissues of this central portion, or stele, are strong and that they are so constructed that liquids may pass along them. Examination will show that our surmise is correct.

The greater part of the tissues of the stele is composed of vessels, and a vessel botanically is an elongated cell whose end walls have broken down entirely or in part so that, with its neighbours at either extremity, the cell forms a long tube. Not all the cells of the stele are vessels, many of them retain their transverse walls. There are, again, in the stele a number of elongated cells whose cell walls have become hard and thickened; it is these cells, called fibres, which lend strength to the stem. In the wood tissue we find that cells, fibres and vessels all have reinforced walls, brought about by the cellulose of which the young cell walls were composed becoming impregnated with a substance called

lignin, a substance, moreover, which like cellulose contains carbon, hydrogen and oxygen though not in the same proportions.

A closer examination of our cross section will show that there are two groups of wood tissue. On the interior next to and often projecting into the pith, there are a number of bundles of wood tissue, differing in appearance from the main wood tissue. These inner bundles of wood are the first formed wood elements or protoxylem, formed by the procambium. The greater part of the wood, however, arises from the cambium ring. The cells of this first formed wood are always smaller in diameter than those of the later formed wood.

Before we consider in detail the various elements composing the wood, let us examine the annual rings (Fig. 72) for a moment. These rings are conspicuous in the majority of deciduous trees and inconspicuous, irregular or absent in most evergreens, for a reason which will be apparent in a moment. We have said that one of the functions of wood is to serve as a channel for water and dissolved substances from root to leaf. That being so, it is clear that where there are no leaves on the tree there is no need for these watery solutions to pass up the tree; on the other hand, when the tree is in full leaf the call on the conducting tissue is

very heavy. It is hardly surprising then to learn that with the opening of the leaves the cells of the wood tissue which are formed are thin walled and of large diameter. At leaf fall, the cells of the same tissue are produced with thick walls and of small diameter. It is this alternate formation of wide and narrow cells which gives the appearance of rings on a cross section. The autumn formed wood is so close that, without the aid of a pocket lens, the cavities or pores cannot be distinguished; in the depth of winter the formation of wood practically ceases; with the advent of spring, the large diameter tissue is formed; so large are the cells of this tissue that they may be plainly seen with the naked eye in most woods. As the change from the non-porous to the porous tissue is sudden, it imparts to the cross section of the wood the appearance of a ring. Normally a single ring is formed in each year, so that the annual rings afford a guide to the age of the tree. Occasionally more than one ring may be formed in a year, and this is the case when the tree is completely defoliated by insects and, later in the year, sends forth fresh leaves. Frosts binding the tree tightly and other external and unusual conditions may disturb the regular sequence of the autumn and spring wood.

In evergreens there are rarely distinct annual rings and the reason is not hard to find. Evergreens do not shed all their leaves at one time ; there is, with them, no period of absolute quiescence. True, elaboration of food, transpiration and all the various functions of the leaf are not carried on so vigorously in the winter as in the summer, but there is never the perfectly dormant period which we find in the deciduous trees.

In the evergreens of temperate regions this slowing up of the plant activities does cause some differences of structure between the autumn and spring wood, but the activities of the tropical evergreens are equally pronounced the year through, so that even a semblance of an annual ring may be sought in vain. The relationship between the structure of the wood and the nature of plant foliage is very striking and no less important.

The number of annual rings to the inch varies considerably according to the position in the tree, there being fewer in the centre than towards the outside, or conversely in the centre of a tree the annual rings are wider than they are nearer to the surface, and this is important to the timber merchant for, in conifers at any rate, the smaller the proportion of the soft spring

wood the greater the strength of the timber, other things being equal.

Even a casual examination of a cross-cut tree stem will, in most cases, show that the wood of the central portion is different from that nearer to the tissue-forming cambium. Very often this difference is rendered still more marked by the fact that the central wood is not of the same colour as that of the outside ; it is usually, though not invariably, darker. The central wood comprises tissue whose cells have lost their contents, and whose sole function is the mechanical one of supporting the tree ; this is the heartwood. Surrounding the heartwood is the sapwood, the cells of whose tissues still perform their physiological function of affording a channel for the raw food material.

The medullary rays vary in size considerably with the kind of tree. In the cross section of Oak (Fig. 72) they are frequently many cells in width ; in some trees they are so small that they cannot be seen with the naked eye. In tangential section (Fig. 71) the rays are approximately the shape of a double convex lens, with a single cell at either end. In radial section, the medullary rays form lustrous bands (Fig. 70) variously known as "felt," "silver grain" or "mirrors." The medullary rays form channels through which elaborated food material may

pass from one part of the stem to another, they also act as storage tissue and are invariably rich in carbohydrates. The size and number of these rays in cross section are invariably characteristic of the woods to which they belong.

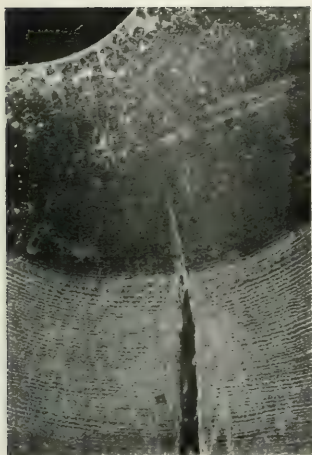
“The elements of the wood are generally parallel in direction to the axis of the stem or limb in which they occur—i.e. the wood is straight-grained; but they may be spirally twisted round the stem, or oblique, in which latter case, if successive layers lie in opposite directions, the wood is cross-grained. A slightly wavy longitudinal course in the elements of the wood produces the condition known as curly grain (Figs. 74-6), frequent in Maple; whilst slight projections or depressions repeated on the outer surface of successive annual layers produce the bird's-eye and landscape varieties in the same wood. The presence of undeveloped buds or knots as in ‘burrs,’ produced on many trees by the attacks of mites, causes similar ornamental wavings of the grain.

“One main cause of the elements not being vertical is their growth in length and in diameter after leaving the cambium stage. Such growth in length causes the tips of the fibres to crowd in between those above and below, and become interlaced and oblique in direction. This adds to the toughness of the wood and makes

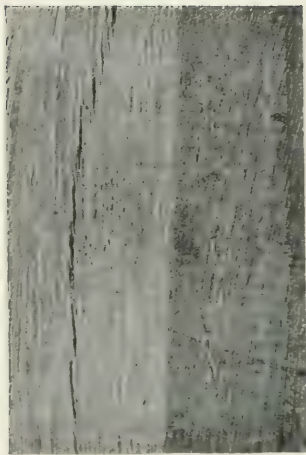
it less easy to split and may produce a visible twisting of stems or branches.

“Another character of some value in discrimination is the occurrence of pith flecks, or medullary spots, dark rust-like patches, which occur in Alder, Birch, Hazel, Hawthorn, and some species of Willow, Poplar and *Pyrus*. They are supposed by some authorities to originate in passages bored by the larvæ of a species of insect which live in the cambium, these passages becoming filled up immediately with cellular tissue; but their origin requires further investigation. . . . It may be noted here that, while it is the lignified elements of woods, especially their tracheids and fibres, that give them their chief technological value, it is the stored-up nitrogenous and other more complex, and therefore more chemically unstable, substances that are the most combustible, i.e. the most readily oxidized, and also the most readily decomposed by the attacks of fungi. It is these substances, therefore, that have to be eliminated, or at least taken into account, in the processes of seasoning or preserving timber, and it is their presence which renders sapwood (Fig. 82) generally less durable than the physiologically inert heartwood (Fig. 82).”

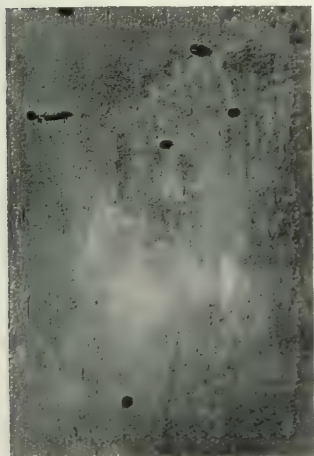
We may well examine a longitudinal section of our stem to learn more of the cells composing



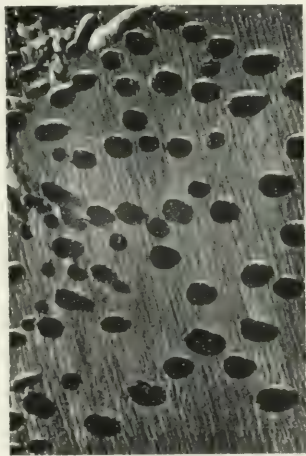
81. A "SHAKE."



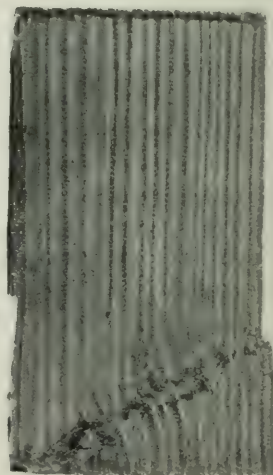
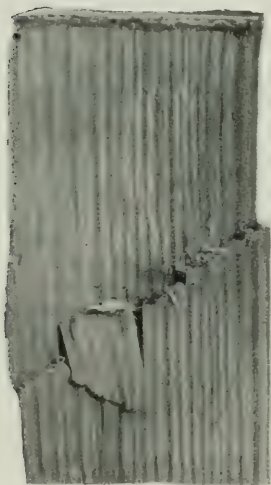
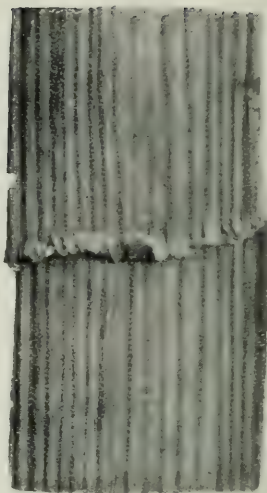
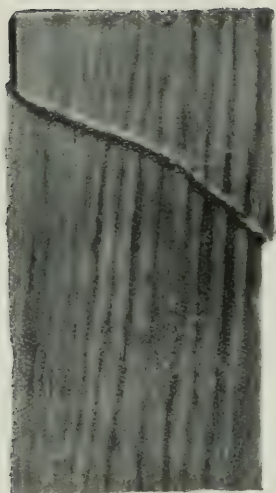
82. WOOD WITH LIGHT HEART AND DARK SAP.



83. "WORM EATEN" WOOD.



84. WOOD DESTROYED BY BEETLES.



85-88. SHOWS VARIOUS EFFECTS OF COMPRESSION ON SOFT WOODS.

the wood and bast. The protoxylem or first formed wood is seen to be composed of a number of elongated cells which have lost their protoplasmic contents, have become lignified as to their walls, the thickening taking the form of annular or spiral bands, much as a reinforced hose-pipe is strengthened by a wrapping of stout wire, with this difference, that in the case of the hose-pipe the thickening or strengthening is external whilst in the wood cells it is internal. These thickened cells may be tracheids or tracheæ, which may be distinguished by the fact that the latter are formed by the fusion of vertical rows of cells and the former are not so formed. The protoxylem of conifers consists of tracheids and tracheæ, that of the broad-leaved trees consists of tracheæ. In the latter trees the secondary xylem or later formed wood is of a somewhat complex nature, and we must refer the reader to a textbook of botany for precise details. Suffice it to say that this secondary wood may comprise tracheids, tracheæ, wood fibres, fibrous cells with either thick or thin walls and wood parenchyma; the one kind of cells which are always present are the tracheæ or true vessels.

In longitudinal section, the bast is seen to be composed of hard and soft bast; the hard bast again is composed of bast fibres, whereas three

elements, bast parenchyma, sieve tubes and companion cells, compose the soft bast. The bast fibres are very long narrow cells with much thickened walls, so much so at times that they are almost solid; on their lateral walls there are many unthickened places which appear as transparent spots when magnified; these are known as pits. The bast parenchyma consists of rows of several slightly elongated cells each one of which contains protoplasm and often starch. The sieve tubes are the vessels through which the elaborated food material passes; they are composed of vertical rows of elongated cells whose end walls are perforated by numerous pits, hence they are termed sieve plates; they contain protoplasm. The companion cells are so called because they are always adjacent to the sieve tubes; they contain protoplasm and their walls exhibit no pits or perforations of any kind. Companion cells are not to be found in the bast of conifers.

It is the custom to deride the use of the microscope as an aid to the study of timber. True the microscope will not and cannot tell us much that we would know concerning wood, but it will at least help towards a better understanding of the reason why certain woods are more suitable for certain purposes than other apparently closely allied woods. The micro-

scope might be used to a much greater extent than up to the present as an aid to classification, and on this point we cannot do better than quote Mr. Herbert Stone, who, in his work on the identification of the timbers of commerce says, "Little attempt has been made to classify woods according to their structure; yet there are characters which seem to have a distinct systematic value. The primary distinction between the wood of the monocotyledonous trees and that of the broad-leaved trees and the conifers is very definite and well known. The next, between the wood of the two latter groups, is equally emphatic and in accordance with the natural system. Up to this point the structure of wood has long been accepted as being of equal systematic value to that of any other part of the plant. Taking the conifers in their turn, there are reliable differences between the woods of the Pines and their allies, and those of the Cedars, Cypressess, etc., and there is a further sharp distinction between those coniferous woods with vertical resin canals and those in which they fail. But, when dealing with the wood of the broad-leaved trees, the systematic botanists cannot be followed; and though characters run through long series of species, genera and even orders, there are so many exceptions that the task of reducing them

to an orderly arrangement seems almost impossible.

“It is not unnatural to assume that woods possessing two kinds of rays should be grouped apart from those having but one kind ; but by separating them we cut off the Cupuliferæ, the Casuærineæ and the Proteaceæ, and perhaps many other orders yet unworked, from the remainder of the broad-leaved trees, making an artificial group of unrelated plants. Therefore our classification cannot be based upon this feature. The arrangement of the pores is very characteristic of many orders, and is very constant throughout long series of species, as the Cupuliferæ, the Myrtaceæ, the Proteaceæ and the Urticaceæ, but similar arrangements of the pores can be found in quite unrelated orders.

“Again, the soft tissue or wood parenchyma is equally casual in its appearance, and, from the study of Solereder’s work, I conclude that the minute structure of the wood, the pitting of the cells, etc., is also unsuitable as a basis.

“Any one of the various kinds of tissue may be absent except the wood fibres and rays, and the following alternatives may be found.

1. Wood fibres and rays.
2. Wood fibres, rays and pores (vessels).
3. Wood fibres, rays, pores and soft tissue (wood parenchyma).

4. Wood fibres, rays of two kinds and soft tissue.
5. Wood fibres, rays of two kinds and soft tissue of two systems.
6. Wood fibres, rays of two kinds, no pores, but vertical resin canals.
7. Wood fibres, rays of two kinds, but no pores (vessels) or resin canals.

“The first class may be neglected as being rare, but the others are very constant, and the presence or absence of one or more of these tissue systems may serve as a foundation upon which to build a key.”

Various additional properties of wood are used as a basis for rough classification; amongst these properties may be mentioned hardness, weight, colour, odour, colour of a solution in water or alcohol and the nature of the ash produced in burning.

We have dealt with the question of weight and specific gravity elsewhere. Hardness “may be expressed with precision by the number of kilograms required to sink a punch one centimetre square to the depth of 1.27 m.m. perpendicularly to the fibres of the wood, or by the number of pounds per square inch to produce such an indentation.”

According to this standard the woods may be

278 TIMBERS AND THEIR USES

grouped roughly in six grades, as quoted by Professor Boulger.

1. Hardest, such as the Ironwood of India, *Mesua ferrea*, which turns the edge of almost any tool, and Lignum Vitæ (*Guaiacum*), which requires 793 kilogrammes to produce the standard indentation.
2. Very hard, requiring more than 3,200 lbs. per square inch, such as Hickory and good Oak and Elm.
3. Hard, requiring from 2,400 lbs. to 3,200 lbs., such as Ash, Walnut, Beech, Holly, Sycamore and Sweet Chestnut.
4. Medium, requiring from 1,600 lbs. to 2,400 lbs., such as Douglas Fir.
5. Soft, requiring less than 1,600 lbs., such as the majority of coniferous woods, Pine, Spruce, Cedar, Poplar, Linden and Horse Chestnut.
6. Very soft, such as the so-called Cotton Tree of India (*Bombax malabaricum*), which is so soft that a pin can readily be driven into it with the fingers.

“Hardness and density or weight to a great extent vary together. They also increase from the base of a stem up to its first branch and decrease from that point upward.”

Stone gives eight grades of hardness as follow :—

1. Excessively hard. Lignum Vitæ, Ebony.
2. Extremely hard. Boxwood, Lilac, Jarrah, Karri, Blue Gum.
3. Very hard. Whitethorn, Blackthorn, Persimmon.
4. Hard. Hornbeam, Elder, Yew, Laburnum.
5. Rather hard. Ash, Holly, Plum, Common Elm.
6. Firm. Teak, Chestnut, Beech, Walnut, Apple, Oak.
7. Soft. Willow, Deal, Horse Chestnut, Alder, Australian Red Cedar, Birch, Hazel, English Cherry, Canary Whitewood.
8. Very soft. White Pine (American), Poplar, Lime, Sequoia.

Colour in many cases is a useful guide to the identity of the wood; the rich brown of the Walnuts, for instance, renders them distinct from all other woods. In many cases, however, the colour even of sound wood is variable; there are for instance at least four varieties of the Locust Tree or False Acacia (*Robinia pseudacacia*) (Fig. 23); one variety, and the best, is red, another is green, another black and yet a fourth yellowish.

Neither the colour, nature of solution, colour

of ash or odour can be reduced to such definite terms as to be of much use in classification. It must be admitted, however, that many woods have a distinctive odour, especially when freshly cut ; amongst them we may mention Camphor, Stinkwood, Cedar, Sandal, Toon, Sneezewood, etc., and the resinous conifers. .

CHAPTER IX

SEASONING OF WOOD

THE efficient seasoning of wood is one of the points concerning which the timber merchant must perforce pay special attention. For every purpose it is essential that wood be properly seasoned. Unseasoned or badly seasoned wood is liable to set up defects which would not occur had proper attention been paid to its treatment. It may warp, it will not take a finish, it will not take glue, it is liable to fungus attack; these and a dozen other evils follow in the wake of the user of unseasoned or improperly seasoned wood.

As a preliminary, careful attention should be paid to the time and method of felling. The wood should be mature, the heartwood uniform and well grown, the sapwood not in excess. Immature wood with excessive sapwood is never durable. "Oak, for instance, for building should not be less than 50 nor more than 200 years old, and Teak not less than 80 years of age."

The time of felling is said to be important

also, and that autumn and winter-felled wood, other things being equal, is of better quality and less liable to subsequent mishap than spring and summer-felled wood, but on this point let us quote Professor Record.

“It is generally believed that winter-felled timber has decided advantages over that cut at other seasons of the year, and to that cause alone are frequently ascribed much greater durability, less liability to check and split, better colour and even increased strength and toughness. The conclusion from the various experiments made on the subject is that while the time of felling may, and often does, affect the properties of the wood, such result is due to the weather conditions rather than to the condition of the wood.

“There are two phases of this question. One is concerned with the physiological changes which might take place during the year in the wood of a living tree. The other deals with the purely physical results due to the weather, as differences of temperature, humidity, moisture and other features to be mentioned later.

“Those who adhere to the first view maintain that wood cut in summer is quite different in composition from that cut in winter. One opinion is that in summer the ‘sap is up,’ while in winter it is ‘down,’ consequently winter-

felled timber is drier. A variation of this belief is that in summer the sap contains certain chemicals which affect the properties of the wood and does not contain them in winter. Again it is sometimes asserted that wood is actually denser in winter than in summer, as part of the wood substance is dissolved out in the spring, and used for plant food, being restored in the fall.

“It is obvious that such views could apply only to sapwood since it alone is in living condition at the time of cutting. Heartwood is dead wood and has almost no function in the existence of the tree other than the purely mechanical one of support. Heartwood does undergo changes, but they are gradual and almost entirely independent of the seasons.

“Sapwood might reasonably be expected to respond to seasonal changes, and to some extent it does. Just beneath the bark there is a thin layer of cells which during the growing season have not attained their greatest density. With the exception of this one annual ring, or portion of one, the density of the wood substance of the sapwood is nearly the same all the year round. Slight variations may occur due to impregnation with sugar and starch in the winter and its dissolution in the growing season. The time of cutting can have no material effect on the in-

herent strength and other mechanical properties of wood except in the outermost annual ring of growth.

“The popular belief that sap is up in the spring and summer and is down in the winter has not been substantiated by experiment. There are several differences in the composition of sap, but so far as the amount of sap in a tree is concerned there is fully as much, if not more, during the winter than in summer. Winter-cut wood is not drier, to begin with, than summer-felled—in reality, it is likely to be wetter.

“The important consideration in regard to this question is the series of circumstances attending the handling of the timber after it is felled. Wood dries more rapidly in summer than in winter, not because there is less moisture at one time than another, but because of the higher temperature in summer. This greater heat is often accompanied by low humidity, and conditions are favourable for the rapid removal of moisture from the exposed portions of the wood. Wood dries by evaporation, and other things being equal, this will proceed much faster in hot weather than in cold.

“It is a matter of common observation that when wood dries it shrinks, and if shrinkage is not uniform in all directions the material pulls apart, causing season checks. If evaporation

proceeds more rapidly on the outside than inside, the greater shrinkage of the outer portions is bound to result in many checks, the number and size increasing with the degree of inequality of drying.

“In cold weather drying proceeds slowly but uniformly, thus allowing the wood elements to adjust themselves with the least amount of rupturing. In summer, drying proceeds rapidly and irregularly, so that material seasoned at that time is more likely to split and check.

“There is less danger of sap rot when trees are felled in winter because the fungus does not grow in the very cold weather, and the lumber has a chance to season to below the danger point before the fungus gets a chance to attack it. If the logs in each case could be cut into lumber immediately after felling, and given exactly the same treatment, for example, kiln-dried, no difference due to the season of cutting would be noted.”

The conversion of timber is also important. The timber for efficient seasoning should be quarter or “rift” sawed, that is cut radially. It is more expensive than tangential sawing, but provides wood of better wearing qualities. Cutting radially also avoids the undesirable feature of having an outside and an inside to each board, a state of affairs which leads to the

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rapid shelling out of the inner rings if the inside be exposed.

“By girdling standing timber the process of seasoning is to a great extent anticipated. Thus, in order to float the timber, which in its green state is at least as heavy as water, it is the general practice in Burma to cut a complete ring through the bark and sapwood of the Teak three years before it is intended to fell it. This stoppage of all ascending sap kills the tree in a few weeks : the heat of the climate helps the seasoning process ; and, as usually about a year elapses between the felling of the timber and its delivery in England, it is then fit for immediate use. It is recommended that the dense Australian timbers should, like Teak, be ringed while standing. This should be done a year or more before felling, and between April and August when the sap is quiescent. The tree is most thoroughly drained of its sap when thus left vertical. It has, however, been objected to this process, that it causes or intensifies heartshake, and, by drying the wood too rapidly, renders it brittle and inelastic.”

Into the various theories concerning the chemical changes which take place during seasoning, we do not propose to enter here. They are not fully understood, but one thing is certain—seasoning does not merely imply drying

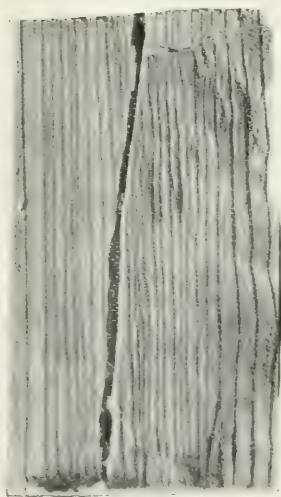
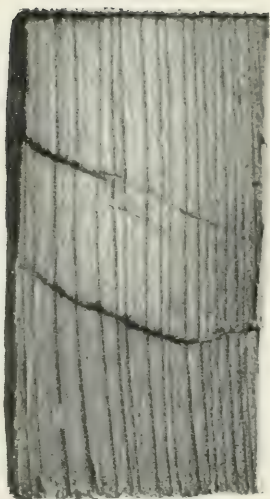
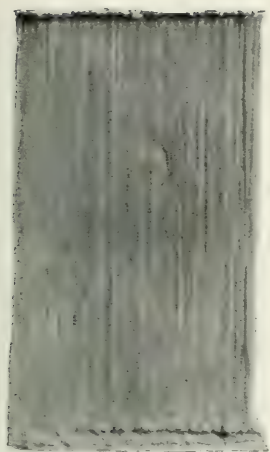
the wood, it is necessary also to decompose the albuminous matter which still remains in the tissues.

Dry wood is stronger than green, tests have proved the truth of this statement over and over again; furthermore properly seasoned wood is not liable to the changes of shape and form which characterize green wood. It is important, however, that seasoning, whether natural or artificial, be properly carried out, or the exterior of the wood will be thoroughly dry before the interior has lost any considerable portion of its moisture. On this question we may again quote Professor Record who says: "In green wood the cells are all intimately joined together and are at their natural or normal size when saturated with water. The cell walls may be considered as made up of little particles with water between them. When wood is dried the films of water between the particles become thinner and thinner until almost entirely gone. As a result the cell walls grow thinner with loss of moisture—in other words, the cell shrinks.

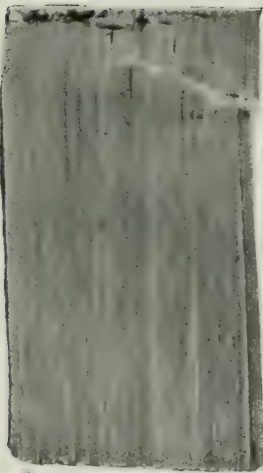
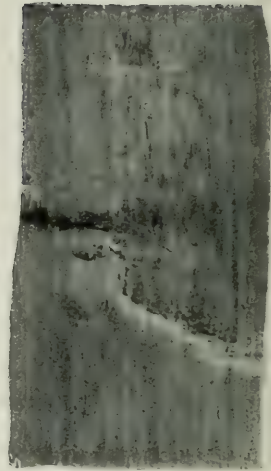
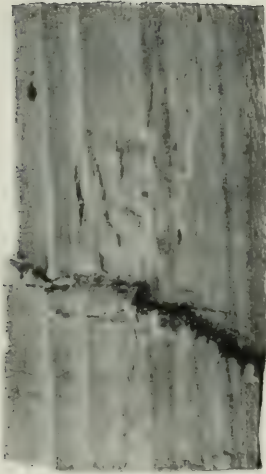
"It is at once evident that if drying does not take place uniformly throughout an entire piece of timber, the shrinkage as a whole cannot be uniform. The process of drying is from the outside inward, and if the loss of moisture at the surface is met by a steady capillary current of

water from the inside, the shrinkage, so far as the degree of moisture affected it, would be uniform. In the best type of drying kilns this condition is approximated by first heating the wood thoroughly in a moist atmosphere before allowing drying to begin.

“ In air seasoning and in ordinary kilns this condition is not so often attained, and the result is that a dry shell is formed which encloses a moist interior. Subsequent drying out of the inner portion is rendered more-difficult by this ‘case-hardened’ condition. As the outer part dries it is prevented from shrinking by the wet interior, which is still at its greatest volume. This outer portion must either check open or the fibres become strained in tension. If this outer shell dries while the fibres are thus strained they become set in this condition and are no longer in tension. Later, when the inner part dries, it tends to shrink away from the hardened outer shell, so that the inner fibres are now strained in tension and the outer fibres are in compression. If the stress exceeds the cohesion, numerous cracks open up, producing a ‘honey-combed’ condition, or ‘hollow horning,’ as it is called. If such a case-hardened stick of wood be resawed, the two halves will cup from the internal tension and external compression, with the concave surface inward.



89-92. SHOWS VARIOUS EFFECTS OF COMPRESSION ON SOFT WOODS.



93-96. SHOWS VARIOUS EFFECTS OF COMPRESSION ON SOFT WOODS.

“For a given surface area the loss of water from wood is always greater from the ends than from the sides, due to the fact that the vessels and other water-carriers are cut across, allowing ready entrance of drying air and outlet for water vapour. Water does not flow out of boards and timbers of its own accord, but must be evaporated, though it may be forced out of any sappy specimens by heat. In drying a log or pole with the bark on, most of the water must be evaporated through the ends, but in the case of peeled timbers and sawn boards the loss is greatest from the surface because the area exposed is so much greater.”

Into the relative merits of natural versus artificial seasoning we do not propose to enter. There are, however, drying kilns on the market at the present time which are far in advance of anything that was obtainable even a few years ago, and, as our knowledge of artificial seasoning advances, there will probably be, if there be now, nothing to choose between the two methods. Natural seasoning is of necessity slower, and in respect of time saving alone there is no doubt as to which is the better process. Artificial seasoning may be either by hot air or by steam drying; the former is the more rapid, but expensive. In any event wood which has had at least a short period of natural or air

drying is likely to give better results by kiln drying than newly felled timber.

There are various impregnation methods of seasoning, many of them of doubtful utility. The object of such methods is to replace the sap by some antiseptic substance. Most of the methods of impregnation in general use are named after their discoverers, thus Burnettizing the wood or impregnating it with zinc chloride is due, in the first place, to Sir William Burnett ; Kyanizing, called after its inventor, Kyan, consists in impregnation with corrosive sublimate which forms insoluble compounds in the tissues, but the method is expensive and corrosive sublimate is highly poisonous.

Powellizing consists in boiling the wood in a sugar solution and then drying at high temperatures. This is one of the most rapid of all methods for seasoning wood, and wood so treated may be seasoned within a few days of being felled.

Other substances commonly used for chemically seasoning wood are copper sulphate, which renders the wood brittle and is not lasting ; creosote, which is cheap and effective ; carbolic acid, equally effective but more expensive ; ferric tannate ; borax ; a mixture of iron and copper sulphates with kainite, and various modifications which are the subject of patents.

Impregnation methods are also performed with the object of rendering wood fire-proof. Of the substances used for this purpose the best known are ammonium phosphate, ammonium sulphate, and boric acid and sodium tungstate.

CHAPTER X

TIMBER TESTING

EVERYONE who is practically interested in timber desires to know something of its properties. Needless to add that the properties essential for the various uses to which wood is put, are as varied as are those uses. The suitability of a timber for a special purpose may be discovered in two ways, either by practical tests in actual use or by tests in the laboratory. If the latter tests are carefully carried out by recognized and well-tried methods, they have much to recommend them, for the results may be expressed in terms which serve for comparison with other similarly tested woods. Unfortunately it is only in quite recent years that anything worthy of record has been accomplished in the matter of timber testing in this country ; it is to America, Canada and Australia that we must turn for our information on this important subject. In the little serious testing that has been done in Britain, there appears to be a tendency to regard the timber under test as a

homogeneous substance, and not as a natural product, which was once as much a living being, subject to various outside influences, as the experimenter himself. A few trial experiments, with specimens cut from the same board, will show that an experimental beam cannot be regarded in the same light as a bar of steel.

The late Professor J. B. Johnson, in his "Materials of Construction," attributed the often apparently inexplicable results obtained in timber testing, to the "variations in the percentage moisture present in the timber," and his work on the subject showed, as far as American woods are concerned, that the strength at 12 per cent moisture was 75 per cent greater than when the wood was green. According to this authority, "It is the absence of any determination of the moisture condition of the test material that vitiates practically all tests of the strength of timber. Since large timbers require many years to season or dry in the open air, while small test sticks dry out very quickly, it is certain that the difference in the moisture conditions will fully explain the marked differences which have been observed in the strength of identical material in different sizes."

Though tests for the moisture content of timber are of such a simple description, that

they can easily be carried out by anyone of average ability, it may be well to describe the methods in brief, for the benefit of those who are carrying out such tests for the first time. It is usual and convenient to express the moisture content as a percentage on the dry weight of timber. Accurate weighing, on a chemical balance, is an essential to success.

The timber to be tested is cut into a small block by means of a chisel; then, by aid of the same tool, the wood block is cut into small pieces and weighed. The test pieces of wood are then put into a drying oven which is maintained at a constant temperature of 200° F. After a period of twenty-four hours or so, the test pieces are removed from the oven and allowed to cool in a desiccator. When cool, the test pieces are weighed and the loss of weight shows the amount of moisture that has been driven off, so that the moisture percentage is easily calculated from the known data.

For more accurate determinations the wood should be repeatedly heated in the oven, cooled and weighed till the weight is approximately constant, i.e. till all the available moisture has been driven off.

We mentioned that the samples should be prepared with a chisel, for the reason that, by this means, less heat is evolved in the working

than in the use of a saw, therefore less moisture is driven off.

Thoroughly over-dry wood retains a small percentage of moisture in the cell walls, but all the free water which may be found within the cells is driven off in the drying process. "Drying produces a decided increase in the strength of wood, particularly in small specimens. An extreme example is the case of a completely dry Spruce block, two inches in section, which will sustain a permanent load four times as great as that which a 'green' block of the same size will support."

Obviously it is important in carrying out any timber testing that due attention should be paid to density. In comparing equal bulks of various dry woods, the heavier woods contain more wood substance than the lighter ones. Various resins and gums which occur in the wood tissues may, however, make the sample with the smaller amount of wood substance appear the heavier. Although practically all woods are considerably heavier than water, it may appear anomalous that the wood should float on water. An examination of any piece of wood cut across the grain will show that it is composed of numerous minute tubes, whose structure and function have already been described. These tubes are, for the most part, filled with

air, a fact which imparts buoyancy to the wood. The density of a sample of wood is merely its weight per unit volume, whether expressed in lbs. per cubic foot or grammes per cubic centimetre. Relative density, more frequently known as specific gravity, is the ratio of the density to that of distilled water at 4° C. Seeing that a cubic foot of distilled water at 4° C. weighs 62.43 lbs., the specific gravity of any substance =

$\frac{D}{62.43}$. Where D = the density per cubic foot.

Or conversely, knowing the specific gravity, it is easy to find the weight per cubic foot, thus $S \times 62.43$, where S = the specific gravity. To find the dry weight per cubic foot, use the formula $W(1 - M)$ lbs., where W = total weight per cubic foot and M = moisture per cent of total weight.

It has been stated that the weight and density of a seasoned timber is to a certain extent a measure of its strength. . . . It is more nearly correct, however, to state that the greater the density and therefore the weight, the greater is the strength to resist compressive strain, whether applied edgewise or crosswise. It has been found that the density is no criterion as to the "Tenacity" or tensile strength of the material, and hence, therefore, affords no guide as to the relative strength of beams which largely involves the tensile strength of the timbers.

Generally speaking, the following deductions as regards density and strength may be accepted:—

1. Timbers in which the grain is closely twisted and interwoven are in general very hard, dense and heavy; high in compressive strength both edgewise and crosswise, and also in shearing strength along the grain; comparatively low in moisture, and, relatively to the straight-grained timbers, are lower in tensile strength, and therefore to a certain extent less strong where used as “beams.”
2. Timbers in which the fibres are straight and even, are relatively less hard and dense, and are lighter; considerably higher in moisture percentage when green; stronger in “tension,” and therefore generally stronger as beams, but are correspondingly lower in compressive strength and in shearing strength along the grain.
3. Timbers lying mid-way between these two conditions, although not so dense and hard as those coming under the first heading, are in general stronger than either.
4. Timbers grown in dry districts have a low

moisture percentage and the sap is of a thick, viscous nature. When cut they season very slowly and shrink to a comparatively small extent in the process.

Timbers growing in loose "porous" districts have a higher moisture percentage and the sap is of a more fluid nature. They season more rapidly, but shrink very little in the process.

The straight-grained timbers season more rapidly and shrink to a greater extent than those with lower initial moisture.

Tests designed to show the ultimate strength of wood may take several forms, and should be so modified as to reveal the stress required to produce rupture, under conditions approximating to those to which the wood will be subjected during use. For example, in testing Australian woods for use as sleepers, three items are always considered.

1. The durability of the timber, and its capacity for resisting dry rot, etc.
2. The hardness and toughness of the material to enable it to resist indentation by the rail without tendency to "split" or break up in service.
3. The requisite capacity for retaining the "dog spikes" in place.

Compression Tests. These tests are usually carried out upon short columns of wood, cut in such a manner that compression takes place parallel to the grain of the wood. The ends of the column are planed exactly parallel to one another and the grain of the wood under test must be parallel to the sides of the column. Should the grain and the sides not be parallel, the short column, when under compression, will merely bend sideways with a tendency to slip from its support (Fig. 96). Load is applied to the short column up to the point of failure which may take the form of bending, buckling (Fig. 90), splitting (Fig. 92), or shearing (Fig. 85), or a combination of one or more (Fig. 87). The nature of the failure depends on the structure of the wood under test and on its moisture content.

Tests in America have shown that "the transverse strength of beams at elastic limit is practically equal to the compressive strength of the same material in short columns."

It seems fruitless to describe in detail the various forms of fracture, seeing that the fractures are not in any way typical of definite woods. Thus several short columns, of the nature we have described, cut from different parts of the same log of wood, will show different forms of failure. "In any case the failure starts

at the weakest points and follows the lines of least resistance. The plane of failure, as visible on radial surfaces, is horizontal, and on the tangential surface it is diagonal."

When end compression parallel to the grain is applied to a longer column, the load tends to shorten the column. Should the column be very long in comparison with the diameter, failure does not take place by buckling or splitting or shearing, but by bending. The maximum stress being at the point where the greatest bending takes place and on the concave side. By supporting the column so that bending cannot occur, failure will take place by splitting or buckling. Very frequently, when end compression parallel to the grain is applied to a short column, failure takes place by shearing (Fig. 85).

This shearing stress may be calculated by dividing the load in pounds necessary to cause the shear, by the area of the cross section of the short column in inches. Supposing, therefore, that the cross section is one inch square the shearing stress will equal the load in pounds. Thus should it require a load of 6,720 lbs. to cause a short column 1 inch square to shear, the shearing stress will be 6,720 lbs. per square inch.

"Tests to ascertain the relative strength of

columns of different lengths were made with specimens in which the ratio of length to minimum lateral dimensions ranged between 2/1 and 36/1 at 12 per cent moisture.

“From these tests the following data were obtained :—

1. Up to and including ratios of 12/1 the strength in end compression in all the timbers was fairly constant, and the specimens invariably failed in direct compression.

Under this condition the average strength varied between 11,600 and 8,450 lbs. per square inch. The Modulus of Elasticity in direct compression was in all cases below that obtained in the Cross Bending and Tensile Tests.

Karri, as in other tests, shows the greatest difference between the strength ‘green’ and ‘dry,’ the former being 46 per cent below the latter. The corresponding figures for the other timbers are : Yate 43 per cent, Blackbutt 40 per cent, Tooart 35 per cent, Jarrah 31 per cent, Red Gum 29 per cent, York Gum and Wandoo 23 per cent, Morrell 22 per cent and Salmon Gum 21 per cent.

2. At a ratio of approximately 18/1, the

strength in end compression falls to an extent of 2.9 per cent; in the case of Karri and in that of Tooart, 6.1 per cent (these being the two limits); and the failure in 60 per cent of the tests was by 'side flexure.'

The strength is quickly reduced as the 'column ratio' is increased, and at a value of 36/1, which was the limit tested, the reduction in strength below that, at a 12/1 ratio, varied between 39 per cent (Karri) and 47 per cent (Wandoo).

It was found that the same percentages of reduction were closely followed at higher moisture values; hence, from the data given, the strength of any column at any 'moisture percentage' can readily be computed.

3. In all cases when the failure occurred in direct crushing, the fracture was of a sliding nature, and this 'sliding' *invariably took place in the direction of the annual rings.*

In turned specimens, and in rectangular specimens, wherever sliding occurred in a direction parallel to one of the sides of the specimen, the angle of sliding was always close to 45°.

In nearly all other cases the angle of

sliding lay between 40° and 45° where measured directly in the direction of movement.

Where the specimens failed as 'long columns,' i.e. by lateral flexure, in the majority of cases failure occurred in the direction of *the annual rings*, rather than radially; but in many cases this was not so, apparently due to local inequalities in the specimens."*

The transverse or bending stress of wood may be tested in a number of ways, and there are strong advocates of each method. The methods of loading the beams for testing are usually either central or third point. The reader who desires further information on the subject is referred to Professor S. J. Record's standard work on "The Mechanical Properties of Wood." As the majority of tests of importance in America, Canada and Australia have been performed with central loading, we shall confine our remarks to that method.

The beam for test is cut to a definite size, which may be such as to suit the proportions of the testing machine and the convenience of the operator. It is, however, essential that the

* "The Physical Characteristics of the Hardwoods of Western Australia."

304 TIMBERS AND THEIR USES

dimensions of the beam be accurately measured and that the test piece be precisely rectangular in section.

The beam is then laid upon the supports of the testing machine, and these supports should move in roller bearings as the wood bends. The distance from centre to centre of the supports should be accurately noted, the distance which the beam projects beyond them, or, in other words, the length of the beam, provided it is longer than the distance between the supports, is unimportant. A load of known weight is then gradually applied to the point on the beam mid-way between the supports; with each additional increment of load the deflection of the beam is accurately measured. The addition of load is continued till the beam breaks, and from the data obtained it is possible to deduce the elastic limit of the timber and also its ultimate extreme fibre stress or breaking load. Some explanation of the term elastic limit may be necessary. As each additional load is added to the beam it will be found that, in the initial stages, the removal of the load will result in the wood resuming its original shape. Then comes a point, however, beyond which any additional load will cause the wood to be permanently deflected. The point at which this occurs is known as the elastic limit. It may

be determined from the data obtained in the above test by plotting a graph of load against deflection, usually called a stress strain diagram. Such a diagram will show a straight line for the initial readings which will eventually curve, slightly if the wood is dry, perceptibly if it is green. The point at which the line begins to curve indicates the elastic limit, which may be calculated in pounds per square inch from the same formula as is used in calculating the ultimate extreme fibre stress or breaking load. viz. :—

$$\frac{3 W L}{2 B H^2}$$

Where W = the load in lbs. applied at the centre of the beam.

B = the breadth of the beam in inches.

H = the depth of the beam in inches.

Hardness. Concerning the question of hardness of woods, we have said something in a previous chapter. Hardness there described refers to resistance to indentation, but there is also another form of hardness which it is important to determine, that is to say resistance to wear. This is a very important consideration in wood which is to be used for floors, wood paving, etc. Tests for either form of hardness are made for comparative purposes only.

Other tests to which wood is frequently subjected are impact test, torsion test, cleavage test and various special tests, the details of which may be found in any good textbook on timber testing.

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INDEX

- Abies balsama*, 55, 102
 — *grandis*, 102, 114
 — *pectinata*, 67
Acacia, 17, 110, 219, 221
 — *arabica*, 87, 106
 — *decurrens*, 213
 — *excelsa*, 13, 111
 — false, 91, 279
 — *harpophylla*, 96, 112
 — *melanoxyton*, 58, 110
 — *pendula*, 96, 112
 — *saligna*, 213
 — *stenophylla*, 111
Acajou, 94, 104
Acapu, Backheart, 81
 Accidents during growth,
 153
Acer barbatum, 72, 103
 — *campestre*, 24, 114
 — *macrophyllum*, 45, 102
 — *platanoides*, 59, 114
 — *pseudo-platanus*, 97, 104,
 115
 — *rubrum*, 85, 103
 — *saccharinum*, 45, 103
Achras sapota, 49, 106
Acle, 4, 17, 60, 62, 69, 74,
 81, 104, 106
Acronychia Baueri, 50, 110
Adina cordifolia, 54, 107
Aecidium abietinum, 151
Aesculus glabra, 101
 — *hippocastaneum*, 38, 101,
 114
Afzelia palembanica, 79, 108
Agallocha, Black, 51
Agaricus melleus, 146
Agathis, 3
 — *australis*, 79, 112
 — *robusta*, 14, 112
Agila Wood, 51
Agrilus Beech, 129
 — *politus*, 129
 — *viridis*, 129
Ailanthus, 10, 26
 — *glandulosa*, 10, 26, 109
Akagashi, 17, 69, 106
Akashide, 39
Albizzia fulibrissin, 49, 100
 — *Lebbek*, 10, 101, 109
 — *odoratissima*, 91, 108
Alder, 22, 23, 39, 94, 113,
 131, 144, 211, 279
 — Berry-bearing, 23
 — Black, 22, 94
 — Common, 22, 94, 126,
 129, 272
 — White, 69
 — — Cape, 39, 99
Alerce, 9
 Alkaline process, 239
Almond, Wild, 17, 39, 82,
 99
Alnus glutinosa, 22, 94, 113
Aloes Wood, 51, 52
Alphitonia excelsa, 112
Alstonia scholaris, 83, 107
Amandelbloom, 82

310 TIMBERS AND THEIR USES

- America, Forestry in, 198
Amyris balsamifera, 43, 105
Anacardium occidentale, 23, 100, 107
 Anan, 4, 69, 106
Andira Aubletii, 81
 — *inermis*, 6, 104
 Angelin, 6, 69, 104
 Angeliue, 69, 104
 Angelly, 6, 69, 106
 Angico, 82, 104
 Angiosperms, 258, 259
Angophora intermedia, 87, 110
 — *subvelutina*, 87, 110
 Anjan, 5, 6, 36, 74, 106
 Annual rings, 259, 265, 267, 268, 303
 Ants, White, 135, 137
Aphides, 117, 125, 127
Apodytes dimidiata, 86
 Apple, 82, 101, 106, 113, 126, 133, 144, 250, 279
 — Black, 6, 110
 — Broad-leaved, 36, 87, 110
 — Crab, 82
 — Narrow-leaved, 87, 110
 — Oregon Crab, 50, 101
 — Tree, 77
 — Wild, 82
Aquillaria Agallocha, 51, 107
Araucaria, 3
 — *Bidwilli*, 83, 110
 — *Cunninghami*, 14, 112
 Arbor Vitae, 29
 — — Giant, 29
 — — Lobb's, 29
 — — Pacific, 29
Arbutus, 211
 — *Menziesii*, 24, 102, 105
Arctostaphylos pungens, 85, 102
 Arjun, 6, 53, 106
Aromia moschata, 130
Arthrotaxis selaginoides, 42, 110
Artocarpus Chaplasha, 70, 107
 — *hirsuta*, 6
 — *integrifolia*, 59, 105, 107
 — *nobilis*, 43, 107
 Ash, American, 10, 18, 39, 101, 164
 — Bitter, 56
 — Black, 39, 67
 — Blue, 17, 38, 50, 101
 — Blueberry, 10, 50, 110
 — Brown-barked, 40
 — Brush, 50, 110
 — Cape, 18, 40, 99
 — Common, 94
 — English, 39, 94, 99, 113, 118, 124, 126, 133, 134, 135, 144, 151, 160, 163, 164, 180, 201, 202, 205, 245, 246, 247, 250, 278, 279
 — Green, 39
 — Grey, 40
 — Ground, 39
 — Hoop, 39
 — Hungarian, 94
 — Mountain, 22, 39, 43, 77, 124, 126, 133, 212, 219
 — Nova Scotia, 39
 — Oregon, 18, 29, 40, 101
 — Quebec, 39
 — Red, 36, 39, 40, 101
 — Rock, 59
 — Swamp, 39
 — United States, 39
 — Victorian Mountain, 6, 20
 — White, 39
 — — River, 39
 Aspen, 31, 38, 66, 82, 95, 120, 129, 238, 242, 248
 — American, 66, 82, 101
 — Large, 68

- Assagay-boom, 18
- Assegai Wood, 18, 40, 50, 99
- Australia, Forestry in, 216
- Austria, Forestry in, 193
- Azadirachta indica*, 45, 108
- Backheart, Acapu, 81
- Backhousia myrtifolia*, 112
- Bagasse, 7, 11
- Bakula, 6, 40, 106
- Balbul, 51, 69, 75, 87, 106
- Balm of Gilead, 67
- Balsam, 30, 67
- Bandara, 7, 75, 106
- Banksia, 40, 110
 - littoralis*, 40, 110
 - seaside, 40
- Baphia nitida*, 99
- Barberry, 54
- Bark, 264
 - Cinchona, 56
 - Wattle, 165
- Barranduna, 82, 110
- Barringtonia acutangula*, 72, 108
- Barwood, 31
- Basket making, 252
- Basswood, 11, 22, 29, 40, 66, 82, 101, 165, 209
- Bast, 273
- Bay, Bull, 13
- Bead Tree, 40, 106, 107
- Bean, Black, 42, 220
 - Locust, 95
 - Red, 220
 - Tonka, 49, 57
 - Tonquin, 57
 - Tree, 42, 166
 - Trefoil, 9
- Bearberry, 54
- Bearwood, 54
- Beati, 95, 106
- Beech, 22, 23, 27, 33, 40, 63, 69, 75, 82, 101, 113, 118, 119, 121, 124, 127, 129, 133, 144, 146, 150, 160, 162, 163, 164, 165, 166, 174, 181, 193, 196, 209, 220, 229, 250, 278, 279
 - Agrilus, 129
 - American, 22, 40, 51, 101
 - Australian White, 90
 - Black, 29
 - Cape, 18
 - Coccus, 127
 - Copper, 127
 - Entire-leaved, 62
 - Evergreen, 7, 27, 38, 41, 58, 107, 219
 - Leaf-miner, 121
 - Negro-head, 58
 - Red, 40, 243
 - St. John's, 22
 - Water, 31
 - She, 29, 110
 - White, 22
- Beefwood, 11, 36, 41, 46, 97, 110, 220
 - Gedraaid, 46
- Bees, Carpenter, 137
- Beetles, 118
 - Bark, 132
 - Black Pine Bast, 133
 - Death Watch, 137
 - Elm Bark, 133
 - Large Poplar, 130
 - Leaf, 120
 - Longicorn, 130
 - Musk, 130
 - Poplar leaf, 120
 - Small Poplar, 130
 - Willow, 120
- Bee Tree, 29, 95
- Betula*, 4
 - *alba*, 23, 101, 106, 113

312 TIMBERS AND THEIR USES

- Betula lenta*, 18, 101
 — *lutea*, 87, 101
 — *papyrifera*, 66, 101
 — *populifera*, 67, 101
 Bibiru, 63
 Billian, 64
 Billy Web, 58
 Birch, 15, 22, 29, 31, 35, 41,
 82, 89, 101, 106, 113, 129,
 131, 133, 135, 144, 150,
 162, 164, 165, 202, 243,
 250, 272, 279
 — American, 18
 — Black, 18, 62, 110
 — Canoe, 66, 82, 101
 — Cape, 99
 — Cherry, 18, 101
 — Common, 15, 23
 — European, 23
 — Grey, 67, 69, 82, 87
 — Mahogany, 18
 — Mountain, 18
 — New Zealand, 62
 — Oldfield, 67, 101
 — Paper, 67
 — Poplar-leaved, 67
 — River, 18
 — Russian, 23
 — Silver, 23
 — Sweet, 18
 — Tall, 87
 — White, 62, 67, 196
 — Yellow, 18, 41, 87, 101
 Bird's-eye, 271
 Bitterwood, 56
 Biwa, 59
 Blackbutt, 18, 20, 43, 60,
 81, 88, 110, 165, 220, 301
 Black Sally, 58
 Blackthorn, 95, 113, 279
 Blackwood, 18, 29, 41, 82,
 94, 110, 166, 215, 219
 — African, 82
 — Australian, 58
 Blackwood, Bombay, 95
 Bleaching, 241
 — Easy, 241, 243
 Bloodwood, 36, 75, 78, 110
 — Brush, 16, 73
 — Red, 75
 Blueberry, 52
 Bluing, 147
 Boco, 21
Bocoa provacensis, 21, 104
 Bog Onion, 34
 Bois Chaire, 7, 41, 58
Bombax malabaricum, 278
 Boree, 96
 — White, 10
Bostrychidæ, 132, 136
 Bottlebrush, Red, 69, 88,
 110
 Box, 33, 34, 61, 77, 106, 113,
 165, 220, 279
 — Abassia, 33
 — Anatolian, 33
 — Australian, 75
 — Bastard, 19, 57, 67, 77,
 88, 91, 93
 — Benbil, 77
 — Black, 77
 — Brisbane, 69
 — Brown, 88
 — Brush, 69
 — Cape, 35, 83, 99
 — Circassian, 33
 — Cooburn, 77
 — Corsican, 33
 — East London, 38, 83
 — English, 33
 — Grey, 77, 88, 219
 — Gum-topped, 75
 — Jamaica, 63, 69, 104
 — Knysna, 35
 — Partheni, 33
 — Persian, 33
 — Red, 27, 69, 88
 — Scrub, 69, 110

- Box, Turkish, 33
 — West Indian, 63
 White, 69
 — Yellow, 27, 34, 77, 88, 110
Brabejum stellatifolium, 82, 99
 Bracket fungus, 141
 Brazil Wood, 31, 58, 104
 Braziletto, Narrow-leaved, 33
 Bread, St. John's, 95
 Briar, 95, 114
 Bridge Building, 4
 Brigalow, 96
 Brimstone Tree, 32
 Britain, Forestry in, 159
Broussonetia papyrifera, 232
Brya ebenus, 58, 105
Bucida angustifolia, 53, 105
 Buckeye, 83
 — Ohio, 67, 101
 Buckthorn, 83, 99, 106, 114
 — Alder, 23, 99, 106, 114
 — Canadian, 54, 101
 — Sacred Bark, 54
Buddelia salvifolia, 35, 100
 Bug, June, 119, 120
 Building, 5
 Bukkum Wood, 33
 Bullet Wood, 49, 107
 — — Andaman, 5, 75
 Bully, 49
 Bunya-bunya, 41, 83, 110, 220
 Burnettizing, 290
 Butterball, 31
 Butterflies, Harmful, 123
 Butternut, 69, 205, 209
 Butter Tree, 92
 Butterwood, 31
 Buttonwood, 31
Buxus Macowani, 83, 99
 — *sempervirens*, 33, 106, 113
 Caban, 31
 Cabinet Making, 10
Caesalpina, 4
 — *brasiliensis*, 58, 104
 — *melanocarpa*, 89, 105
 — *sappan*, 33
 Cajeput, 19, 36, 70, 110
 Calamander, 83
 Calisaya Tree, 56
Callistemon lanceolatus, 88, 110
Callitris robusta, 63
 Cambium, 263, 264, 265
 Campeachy Wood, 32
 Camphor, 55, 107, 165, 280
 — Nepal, 11, 107
 — Wood, 63
 Camwood, 31, 99
 Canada, Forestry in, 204
 Canary Wood, 27, 32, 36, 51, 63, 75, 83, 99, 107, 110
 — Indian, 11
 Canelle, 7, 11, 104
 Canker, Larch, 148
 Cannonball Tree, 7, 41, 51, 88, 107
 Canoe Wood, 10
 Cape of Good Hope, Forestry in, 211
 Caraba, 43
Carapa, 43
 — *guianensis*, 43, 104
 Carbaballi, 43
 Caribaballi, 43
 Carob, 95, 100, 178
 Carpenter Bees, 137
Carpinus betulus, 27, 107, 114
 Carpy, 27
 Carriage Building, 17
 Carving, 21
 Carya, 102
 Cascara sagrada, 54
 Case-hardening, 288

314 TIMBERS AND THEIR USES

- Cashew nut, 23, 70, 100, 107
Cassia siamea, 95, 106
Castanea vulgaris, 23, 102, 114
Castanospermum australe, 42
Casuarina Fraseriana, 47, 112
 — *glauca*, 112
 — sp., 218, 220
 — *stricta*, 86, 112
 — *torulosa*, 46
Catalpa, 36, 101
 — *speciosa*, 36, 101
Ceanothus chloroxylon, 27, 104
 Cedar, 16, 21, 41, 42, 95, 104, 165, 199, 205, 209, 211, 215, 275, 278, 280
 — Atlas, 11, 75, 100
 — Australian Pencil, 34, 110
 — Barbados Bastard, 95
 — Bastard, 21, 41, 42, 71
 — Pencil, 11, 110
 — Cairn's, 13
 — Pencil, 13
 — Canadian Red, 29
 — Canoe, 7, 29, 36, 41, 70, 102
 — Cape Red, 11
 — Cigar Box, 95
 — Cuba, 95
 — Deodar, 41, 63, 76, 107
 — Giant, 29
 — Guiana, 7, 70, 104
 — Havannah, 95
 — Honduras, 95
 — Incense, 36, 41, 102
 — Jamaica, 95
 — Japanese, 53
 — Mexican, 95
 — Moulmein, 21, 41, 70, 107
 — North Western Red, 29
 — Oregon, 36, 38, 70, 102
 Cedar, Pencil, 13, 42, 70, 96, 102
 — Port, 41
 — Port Orford, 70
 — Red, 29, 41, 76, 83, 166, 200, 205, 210, 220, 279
 — Cape, 88, 100
 — Rock, 36, 76, 81, 104
 — Sitka, 76
 — Tasmanian, 42, 70, 110
 — Western White, 29
 — West Indian, 95
 — White, 29, 37, 40, 41, 63, 70, 76, 102
 — Yellow, 29, 36, 70, 76, 102, 205, 210
Cedrela, 4
 — *guianensis*, 94, 104
 — *odorata*, 95, 104
 — *Toona*, 41, 107, 110
Cedrus atlantica, 75, 100
 — *Deodara*, 76, 107
Celastrus acuminatus, 86, 100
Celtis australis, 96, 114
 — *occidentalis*, 89
Ceratonia siliqua, 95, 100
Ceratopetalum apetalum, 19, 111
Ceratostomella pilifera, 147
Cercocarpus, 4
 Cerillo, 27
 Chaire, Bois, 104
Chamaccyparis nutkaensis, 76
 Champak, 7, 42, 70, 107
 Chaplash, 42, 70, 107
 Charcoal, 22
 Charcoal making, 245
 Chatwan, 83, 107
Cheimitobia brumata, 124
Chermes abietis, 127, 128
 — *corticalis*, 127
 — Larch, 128
 — *laricis*, 128
 — *piceæ*, 127, 128

- Chermes pini*, 127
 — *strobilobius*, 127, 128
 Cherry, 51, 83, 96, 102, 114,
 144, 164, 202, 209, 279
 — American, 11
 — Australian Wild, 88
 — Black, 11
 — Brush, 72
 — Garden, 96
 — Sour, 96
 — Wild, 54
 — — Black, 11, 102, 202
 Chestnut, 12, 23, 37, 102,
 114, 126, 144, 162, 178,
 279
 — American, 243
 — Edible, 23
 — Horse, 13, 35, 102, 114,
 135, 278, 279
 — Indian Rose, 44
 — Moreton Bay, 42, 111
 — Spanish, 23
 — Sweet, 23, 278
 Chichipate, 58
Chionaspis salicis, 126
 Chir, 24, 55, 107
 Chittagong Wood, 21, 41, 42,
 107
Chlorophora excelsa, 78, 100
 — *tinctoria*, 32, 105
Chloroxylon swietenia, 106
Chrysomelidæ, 120
Chukrasia tabularis, 21, 42,
 107
 Cinchona, 56
 — Bark, 56
Cincona calisaya, 56, 105
Cinnamomum camphora, 55,
 107
 — *glanduliferum*, 11, 107
 Cirouaballi, Yellow, 42, 104
 Claraiba, 12
 Clearwings, 135
 — Hornet, 135
 Coach Building, 17
 Coachwood, 12, 19, 51, 70,
 111
Coccidæ, 125
 Coccus, Felted Beech, 127
 Cockatoo Bush, 52
 Cockchafer, 118, 120
 Cocobola Wood, 51, 104
 Coconut, Sea, 88
Cocos nucifera, 97, 109
 Cocos Wood, 58
 Coco Wood, 21, 104
 Cocus, 58
 Coffee Tree, 7, 36, 102
 Cogs, 27
 Cogwood, 27, 63, 104
 — Jamaica, 27
Coleoptera, 118
 Compression tests, 299
Connarus guianensis, 50, 106
Convolvulus scoparius, 57, 100
 Cooperage, 29
Copaifera Mopane, 46, 100
 — *pubiflora*, 48, 105
 Copal, Indian, 56
 Copalm, 44
 Coppice, 170, 171, 183
 Coral spot disease, 152
Cordia gerascanthus, 12, 105
 — *myxa*, 73, 100, 109
 Cork, 253
 — Mother, 254
 — Virgin, 254
 Cornel, 24, 34
 Cornelian Wood, 34
Cornus florida, 34, 102
 — *sanguinea*, 24, 107, 114
 Coromandel Wood, 83, 107
 Cortex, 263
Cossus ligniperda, 134
 Cotton Tree, 278
 — — Big, 11, 67
 — varay, 10
 — wood, 11, 67, 202

- Coumarouna odorata*, 57, 106
 Cowrie, 79
 Crab, 82
 — Apple, 82
 — tree, 82
 — Wood, 43, 53, 104
Crataegus oxyacantha, 35, 100
 107, 114
 Crocus tree, 48
 Crossgrain, Local, 157
 Crown forests, 161
Cryphalus abietis, 132
 — *fagi*, 132
 — *piceæ*, 132
 — *tiliæ*, 132
Cryptorrhynchus lapathi, 131
Cryptocarya glaucescens, 29,
 110
Cryptococcus fagi, 127
Cryptomeria japonica, 53,
 109
 Cuamara, 57
 Cucumber Tree, 7, 43, 84, 102
Cunonia capensis, 88, 100
Cupressus Lawsoniana, 102
 — *nutkaensis*, 102
 — *obtus*a, 52, 107
 — *thyoides*, 76, 102
 Currant, 151
 — Native, 52
Curtisia faginea, 18, 99
 Curupay, 5, 88
 Cutch, 165, 215
 Cypre, Bois de, 12
 Cypress, 76, 275
 — Bald, 76
 — Black, 76
 — Deciduous, 76
 — Japanese, 52
 — Lawson's, 70
 — Red, 29, 76
 — Swamp, 37, 76, 102, 199,
 205
 — White, 76
 Cypress, Yellow, 76
Cytisus laburnum, 64, 114
Dacrydium, 3
 — *cupressinum*, 15
 — *Westlandicum*, 79
Dalbergia cultrata, 94
 — *melanoxydon*, 82
 — *nigra*, 60
 — *Sissoo*, 93
 Dammar, Southern, 79
 — White, 56
Daviesia arborea, 15
 Deal, Red, 8
 — White, 26, 68
 — Yellow, 8
 Del, 43
 Density, 295
 Deodar, 21, 42
Dicorynia paraensis, 69
Dicotyledons, 259
Dimorphandra excelsa, 46
Diospyros ebenus, 7
 — *Kurzii*, 45
 — *quaesita*, 83
 — *tetrasperma*, 12
Dodonaea viscosa, 35, 106, 109
 Dogwood, 16, 24, 27, 73
 — American, 34
 — Black, 23
 — Flowering, 34
 — Western, 34
 Dyes, 31
Dysoxylum Fraserianum, 34
 — *rufum*, 11
 — *spectabile*, 13
 Eagle Wood, 51, 107
 Ebony, 279
 — African, 82
 — American, 52, 105
 — Brown, 58
 — Bombay, 7, 21, 107, 115
 — Cuba, 12, 105

- Ebony, False, 84, 114
 — Green, 58
 — Jamaica, 58
 — Senegal, 83
 — West Indian, 58
 — White, 16
Ekebergia capensis, 18, 99
Elaeocarpus cyaneus, 10, 110
 — *dentatus*, 78, 111
Elaeodendron croceum, 48, 100
Elaphidion villosum, 130
 Elder, 279
 — Box, 67
 Elm Bark Beetle, 133
 Elm, 19, 84, 115, 118, 119,
 123, 126, 133, 134, 135,
 155, 160, 163, 164, 165,
 180, 202, 203, 205, 209,
 250, 278, 279
 — American, 19, 30, 51, 89,
 102
 — Canadian, 19, 30, 63, 89,
 102
 — Chair, 70
 — Common (see Elm)
 — Cork, 19
 — Crow's foot, 65
 European, 19
 False, 89
 — Hickory, 19
 — Japanese, 52
 — Moose, 37, 70, 102
 — Mountain, 70
 — Nova Scotia, 30
 — Red, 30, 70
 — Rock, 19
 — Scotch, 70
 — Slippery, 70
 — Spanish, 12
 — Spreading, 12, 84, 115
 — Swamp, 19, 30
 — Water, 30
 — White, 19, 30
 — Wych, 70, 115, 124
 Els, 22, 59, 100
 Engraving, 33
Enterolobium timbuova, 48,
 105
Erica arborea, 95, 114
Eriobotrya japonica, 59, 108
Erysiphæ, 144, 150
Eucalyptus, 4, 166, 212, 217
 — *corymbosa*, 75, 110
 — *corynocalyx*, 64, 111
 — *crebra*, 78, 111
 diversicolor, 112
 — *globulus*, 19, 111
 — *gomphocephala*, 74, 113
 Gunnii, 111
 — *haemastoma*, 111
 — *hemiphloia*, 75, 110
 — *Laemastoma*, 20
 — *largiflorens*, 77, 111
 — *longifolia*, 93, 113
 — *macrorrhyncha*, 93
 — *maculata*, 111
 — *marginata*, 61, 112
 — *meliadora*, 34, 110
 — *microcorys*, 62, 113
 — *microtheca*, 221
 — *obliqua*, 113
 — *paniculata*, 78, 111, 112
 — *patens*, 88
 — *pilularis*, 110
 — *polyanthema*, 88
 — *populifolia*, 77, 111
 — *punctata*, 91
 — *redunca*, 81, 113
 — *resinifera*, 65, 112
 — *robusta*, 112
 — *rostrata*, 64, 111
 — Salmon-barked, 89
 — *salmonophloia*, 89, 111
 — *salubris*, 35, 111, 221
 — *siberiana*, 111
 — *siderophloia*, 61, 111
 — *Stuartiana*, 77, 111
 — *tereticornis*, 77, 111

318 TIMBERS AND THEIR USES

Euclea undulata, 48, 100
Eucryphia Moorei, 17, 110
Eugenia myrtifolia, 72, 112
Euonymus europaeus, 25,
 100, 109, 115
 — — var. *Hamiltonianus*,
 35, 108
Eusideroxylon Zwageri, 64,
 107
 Evaporation, 231
Exocarpus cupressiformis, 88

Fagara flava, 49
Fagraea fragrans, 4, 106
Fagus Cunninghamii, 58, 110
 — *ferruginea*, 40, 101
 — *solandri*, 62, 110
 — *sylvatica*, 22, 101
 Felted Beech Coccus, 127
 Fencing, 36
 Finishing Wood, 251
 Fir, American Silver, 55
 — Balm of Gilead, 55
 — Baltic, 8
 — Balsam, 30, 55, 102
 — Danzig, 8
 — Douglas, 54, 200, 205,
 211, 278
 — Great, 12, 30, 102
 — Hemlock, 78
 — Norway, 8
 — Red, 54
 — Scots, 8
 — Silver, 24, 37, 67, 71,
 114, 122, 128, 132, 134,
 163, 164, 174
 — Spruce, 26, 68
 — Swedish, 8
 — Tall Silver, 30
 — Western White, 30
 — White, 26, 68
 — White Sea, 8
 — Yellow, 54
Flindersia Oleayana, 71, 112

Flooring, 38
 Forestry in Algeria, 179
 — — Australia, 216
 — — Austria, 193
 — — Britain, 161
 — — Canada, 204
 — — Cape of Good Hope,
 211
 — — France, 166
 — — Germany, 180
 — — India, 214
 — — Italy, 190
 — — Natal, 214
 — — Norway, 197
 — — Russia, 198
 — — Sweden, 196
 — — Switzerland, 187
 — — United States of
 America, 198
 Forests: Alice Holt, 162;
 Athole, 162; Bere, 162;
 Chopwell, 162; Dean, 16,
 162; Delamere, 162;
 Hazleborough, 162; Mans-
 field, 162; New, 161, 162;
 Parkhurst, 162; Salcey,
 162; Sherwood, 161;
 Woolmer, 162
 Formation of wood, 257
Fraxinus americana, 18,
 39
 — *excelsior*, 94, 99, 113
 — *oregona*, 18, 29
 — *quadrangula*, 17
 — *sambucifolia*, 39
 Free miners, 162
Frenela, 3
 — *parlatorei*, 12
 — *robusta*, 111
 Fuel, 249
 Fungoid Pests, 137
 Fungus, Bracket, 141
 Funera, 43
Furetage, 173

- Furniture, 39
 Fustic, 32, 105
 — Wood, 32

 Gambier, 165
 Gamboge, 32, 107
Garcinia Hanburyi, 32, 107
 Geelheart, 63
 Geelhout, Cape, 39
 Germany, Forestry in, 180
 Girdlers, 117, 129
 Girdling, 286
Gonioma Kamassi, 100
 Granadillo, 7, 43, 58, 105
 Grandillo, 58
 Grain, Cross, 157, 271
 — Curly, 271
 — Diagonal, 158
 — Silver, 270
 Gravity, Specific, 296
 Great Britain, Forestry in, 159
 Green fly, 117, 125
 Greenheart, 5, 63, 89, 105, 155, 165
 — Yellow, 63
 Grenadilla Wood, 83
Grevillea striata, 41, 110
 Grignon, 43, 53, 105
 — Fou, 54, 105
 Growth, Accidents during, 153
Guaiacum, 278
 Guarabu, 71, 105
 Gums, 165
 Gum, Apple, 37, 43
 — Apple-scented, 77, 111
 — Bally, 38
 — Bastard, 24
 — Black, 16
 — Blue, 19, 20, 64, 71, 77, 89, 90, 111, 212, 215, 279
 — Botany Bay, 65
 Gum, Broad-leaved, 20, 37
 — — — water, 64, 77, 111
 — Brown, 72
 — Cabbage, 7, 37, 43, 111
 — Californian Red, 44
 — Cider, 24, 111
 — Copal, 165
 — Cotton, 16
 — Creek, 64
 — Flooded, 64, 77
 — Fluted, 35
 — Forest, 64
 — — Red, 220
 — Gimlet, 35, 43, 111, 218, 221
 — Grey, 19, 65, 77, 91, 220
 — Honey-scented, 34
 — Kauri, 166
 — Mahogany, 61
 — Manna, 218
 — Merrell, 218
 — Mountain, 7, 37, 77, 111
 — Murray Red, 64
 — Nankeen, 7, 37, 77, 111
 — Poplar-leaved, 88
 — Red, 5, 34, 44, 51, 64, 65, 77, 89, 91, 111, 166, 212, 217, 218, 219, 220, 301
 — River, 64
 — Salmon, 64, 89, 111, 218, 301
 — Scribbly, 20, 38, 111
 — Slaty, 7, 27, 37, 77, 111
 — Sour, 16
 — Spotted, 20, 61, 71, 111, 219, 220
 — Star-leaved, 44
 — Sugar, 24, 37, 64, 77, 89, 111, 212, 218
 — Swamp, 24
 — Sweet, 44, 102, 105
 — Top, 43
 — Tupelo, 16

320 TIMBERS AND THEIR USES

- Gum, Water, 27, 88, 111
 — White, 20, 24, 64, 74, 75,
 77, 81, 90, 217, 218
 — Yellow, 16, 24, 91
 — York, 217, 301
 Gutta Percha, 165
 Guyacan, 89, 105
Gymnosperms, 258, 259

 Hackberry, 37, 44, 102
 Hackia, 28
 Hackmatack, 80
Haematoxylon campechianum, 32, 105
Hakea leucoptera, 97, 112
 Haldu, 54, 84, 107
 Hardbeam, 27
 Hardness, 277, 305
 Hardening, Case-, 288
Hardwickia binata, 74, 106
Harpullia pendula, 36, 106
 Harra, 7, 32, 107
 Hassagay Wood, 18
 Hawthorn, 35, 100, 107, 114,
 118, 126, 133, 135, 151,
 250, 272
 Hazel, 124, 144, 250, 258,
 272, 279
 — Wych, 70
 Heart Rot, 144, 147
 Heartwood, 84, 270, 272, 283
 Heaven, Tree of, 26
 Hemlock, 78, 165, 199, 200,
 209, 211
Heritiera fomes, 93, 109
Hevea brasiliensis, 106
 — *guyanensis*, 57
 Hiba, 5, 7, 71, 107
Hickoria ovata, 89
 Hickory, 20, 24, 58, 65, 91,
 102, 164, 201, 205, 209,
 278
 — Shell-bark, 51, 89
 — White, 89

 Hinau, 37, 78, 111, 222
 Hinoki, 107
Hoheria populnea, 44, 112
 Holly, 278, 279
 Honeysuckle, 53
 — Coast, 53
 — New Zealand, 53
 — Silvery, 41
 — White, 53
 — Wood, 31, 53
 Hoobooballi, 12, 105
 Hoop tree, 45
Hopea Maranti, 55, 108
 Hornbeam, 27, 107, 114, 124,
 174, 279
 Hungary, Forestry in, 193
Hybernaria defoliaria, 124
Hylastes ater, 132, 133
 — *palliatu*s, 132, 133
Hylesinus crenatus, 133
 — *fraxini*, 133
 — *oleiperda*, 133
 — *vittatus*, 133
Hylobius abietis, 131
Hylurgus piniperda, 132
Hymenoptera, 121, 137

Icica altissima, 7, 104
 Ilex, 180
Illipe latifolia, 92, 108
 India, Forestry in, 214
 Indiarubber, 165, 166
 Indigo, 32, 107
Indigofera tinctoria, 32, 107
 Injury to timber, 154
 Insects, Leaf-eating, 118
 Insect pests, 116
 Ironbark, 43, 77, 93, 164,
 220
 — Bastard, 43
 — Broad-leaved, 61
 — Grey, 78, 89, 111
 — Narrow-leaved, 78, 111
 — Pale, 78

Ironbark, Red, 61, 78, 111
 — She, 78
 — Silver-top, 219
 — White, 8, 37, 43, 78, 215
 Irontree, 28
 Ironwood, 5, 28, 65, 100, 111, 215
 — Australian, 13, 84, 111
 — Borneo, 8, 64, 107
 — Cape, 71, 100
 — Martinique, 28
 — West Indian, 28
 — White, 71
 Iroko, 7, 78, 100
 Italy, Forestry in, 190
 Ivory Wood, 35, 111
Ixora ferrea, 28, 105

Jaack Wood, 59
 Jaca Tree, 59
Jacaranda brasiliiana, 59, 105
 — *cabiuna*, 60
 — *Preto*, 60
 — Wood, 60
 Jack, 8, 32, 44, 59, 71, 84, 105, 107
 — Lesser, 70
 — Long, 70
 — Thorny, 70
 — Wood, 59
 Jambolana, 8, 20, 79, 108, 112
 Jardinage, 173
 Jarrah, 24, 44, 61, 64, 79, 81, 112, 163, 164, 165, 212, 217, 279, 301, 302
 — Curly, 61
 — Salmon-barked, 89
 Jarul, 8, 20, 71, 90, 108
 Jhand, 8, 20, 44, 90, 108
 Jimmy Low, 65
Juglans australis, 46, 105
 — *nigra*, 16, 104
 — *regia*, 60, 115

Y

June Bug, 119, 120
 Juniper, 84, 114
 — Australian, 8, 13, 52, 112
Juniperus communis, 84, 114
 — *sabinoides*, 76, 104
 Kahikatea, 222
 Kamassi, 13, 35, 100
 Kari, 90
 Karri, 20, 44, 61, 64, 71, 90, 112, 165, 212, 217, 279, 301, 302
 Karst, 194
 Kathitka, 49
 Kauri, 8, 54, 79, 81, 112, 163, 166, 212, 214, 221
 — Queensland, 14
 Kawri, 79
 Kaya, 4, 8, 13, 108
 Keyaki, 52, 108
 Kiamil, 13, 90, 108
 Kiggelaria, 4
 Kino, 166
 Kirton Wood, 90, 112
 Kizi, 52, 108
 Klip, 59
 Klipdorn, 92
 Knobhaut, 90
 Knobthorn, 90, 100
 Knots, 157
 Kohe Kohe, 13, 112
 Koondaba, 47
 Kos, 59
 Kosum, 90, 108
 Kowhai, 28, 112
 Kraft, 241
 Kyanizing, 290
 Laburnum, 279
 Lacebark, 44, 112
 Lacewood, 11, 14, 31, 67, 85
Lagerstraemia flos-reginae, 71
 — *parvifolia*, 75, 106
 — Queen, 71

322 TIMBERS AND THEIR USES

- Laintlaintain, 85
 Lancewood, 164
 — Cape, 18
 Lapacho, 79, 90, 105
 Larch, 13, 37, 64, 79, 90, 91,
 114, 128, 144, 148, 163,
 164, 174, 178, 181, 199,
 209
 — American, 80
 — Black, 80
 — Canker, 148
 — Chermes, 128
Larix americana, 80
 — *europaea*, 114
 — *pendula*, 104
 Lasrin, 22, 44, 91, 108
 Laurel, Big, 13
 — Cape, 9
 — Madrona, 24, 102, 105
 — White, 29
 — Wood, 9
 Leaf beetles, 120
 — miner, Beech, 121
 — beetle, Poplar, 120
 — rollers, 124
 Leather board pulp, 236
 — Jacket, 8, 19, 71, 79, 91,
 112
 Leaves, Insects destroying,
 118
Lecanium capreæ, 126
Lecythis grandiflora, 46, 100,
 105
Legrium Rhodium, 43
 Leichardt's Tree, 32
 Lenticels, 143
 Leopard, Wood, 135
Lepidoptera, 123, 124
Lepidosaphes ulmi, 126
Libocedrus decurrens, 41,
 102
 Light Wood, 19, 58
 Light Yellow Wood, 71
 Lign-Aloes, 51
Lignum Vitæ, 9, 28, 44, 84,
 88, 105, 278, 279
 Lilac, 279
 — Cape, 40
 — Persian, 40
 Lime, 24, 84, 124, 126, 130,
 132, 164, 279
 — Lin, 29, 95
 — Tree, 29, 95
 Linden, 29, 95, 201, 278
Liquidambar styraciflua, 44,
 102, 105
Liriodendron tulipifera, 10,
 104
Litsea reticulata, 38, 110
 Local cross grain, 157
 Locust, 13, 28, 91, 102, 114,
 279
 — Bean, 95
 — Black, 13, 64, 79, 85, 91
 — Red, 91
 — Yellow, 91
 Logwood, 32, 105, 106
 Longicorn beetles, 130
Lophira alata, 85, 100
Lophyrus pini, 121
 Loquat, 59, 108
Lucuma galastoxylon, 13

Maclura aurantiaca, 61, 103
 Madrona, 24
 — Madera, 24
Magnolia acuminata, 84, 102
 — *grandiflora*, 13, 102
 — Large-flowered, 13, 102
 — Mountain, 84
 Mahogany, 32, 64, 78, 164,
 166
 — Australian, 34, 47, 61
 — — Red, 65
 — Bastard, 20, 41, 61, 71
 — Birch, 18
 — Brisbane, 69
 — East Indian, 71, 108

- Mahogany, Forest, 62, 65
 - Gum, 61
 - Indian, 41
 - Mountain, 18
 - New South Wales, 212
 - Red, 61, 65, 112, 220
 - Spanish, 155
 - Swamp, 44, 64, 72, 78, 91, 112
 - Tenasserim, 38
 - White, 72
- Mahwa, 8, 72, 79, 92, 106
- Maidenhair Tree, 258
- Maire, Black, 92, 112, 222
- Mallee, 221
- Manao, 80
- Mangifera indica*, 92, 108
- Mango, 44, 92, 98, 108
- Mangosteen, 108
 - False, 20
 - Wild, 20, 72
- Manufacturers, 332
- Manzanita, 85, 102
- Maple, 13, 24, 45, 85, 114, 124, 144, 150, 164, 165, 203, 205, 209, 211, 271
 - Ash-leaved, 25, 30, 67
 - Big-leaved, 45
 - Bird's-eye, 45, 72
 - Broad-leaved, 45
 - Californian, 45
 - Common, 25
 - Fiddle-backed, 45
 - Field, 25
 - Hard, 72
 - Norway, 59, 84, 114
 - Oregon, 45, 51, 102
 - Plane, 59
 - Red, 45, 85, 103
 - Rock, 45, 72, 92, 103
 - Silver, 45, 103
 - Soft, 45, 85
 - Sugar, 45, 72
 - Swamp, 85
- Maple, Water, 85
- Marblewood, Andaman, 45, 85, 108
- Margosa, 20, 45, 108
- Marlea vitiensis*, 85
- May, 35
- Mechanical brown pulp, 236
 - wood pulp, 233
- Medicine, 54
- Medullary rays, 260, 264, 265
- Megastigmus spermotrophos*, 122
- Melaleuca leucadendron*, 18, 110
- Melia composita*, 40, 106, 110
- Melolontha hippocastani*, 119
 - *vulgaris*, 119
- Meni, 85
- Meraban, 79
- Meranti, 45, 55, 108
- Merban, 79
- Meristem, 261
- Merulius lacrymans*, 151
- Mesquite, 8, 45, 103
- Messmate, 212, 219
- Mesua ferrea*, 44, 107
- Meterosideros robusta*, 73, 113
- Michelia Champaca*, 42, 107
- Mildew, 143, 150
- Milkwood, Red, 92, 100
 - Soft, 71
 - Tree, 19
 - White, 71
- Millai, 85
- Mimosa, Sweet-scented, 91
- Mimusops elengi*, 6, 106
 - *globosa*, 107
 - *littoralis*, 75
 - *obovata*, 92, 100
- Miner's leaf, 121
- Mirabow, 46, 79 108
- Miscellaneous, 94

324 TIMBERS AND THEIR USES

- Mistletoe, 149
 Miva, 13
 Moisture tests, 294
 Molavé, 8, 13, 105
 Monkey Pot, 40, 100, 105
Monocotyledons, 263
 Mopane, 46, 100
 Mora, 46, 72, 105, 166
 Moraballi, 46
 Moreira, 46
Morinda citrifolia, 32, 99, 107
 Morrell, 301
 Morung Sal, 80
Morus alba, 52, 108, 114
 — *rubra*, 72, 103
 Moths, 123
 — Buff-tip, 123
 — Clearwing, 135
 — Goat, 134
 — Hornet Clearwing, 135
 — Mottled Umber, 124
 — Pine Shoot, 125
 — Vapourer, 123
 — Winter, 124
 — Wood Leopard, 135
 Mulberry, 52, 108, 114, 232
 — Dyers, 32
 — Indian, 32
 — Red, 72, 103
 Musical Instruments, 57
 Musk beetle, 130
 — Tree, 85
 — Wood, 14, 85
 Mussel scale, 126, 127
 Myall, 37, 46, 85, 96, 112
 — True, 96
 — Weeping, 96
Myoporum serratum, 52, 112
 Myrobalams, 165
 — Black, 32
Myrsine melanophleos, 18, 99
 Myrtle, 58, 82, 222
 Myrtle, Beech, 82
 — Brigalow, 85, 96, 112
 — Brush, 82
 — Cherry, 82
 — Grey, 85
 — Native, 52, 72, 85
 Nakkern Wood, 73
Nectandra mollis, 7, 104
 — *pisi*, 42, 104
 — *rodioei*, 63, 105
 Needle Bush, 97
Negundo, 67
 — *aceroides*, 67
 Nettle tree, 46, 85, 89, 114
 Nim, 45
 Nispero, 49
 Nogal, 8, 46, 105
Notolaea ligustrina, 84
Nuxia floribunda, 87, 101
 Nym, 45
 Oak, 64, 65, 69, 72, 79, 91, 114, 118, 119, 123, 124, 126, 129, 133, 134, 144, 146, 150, 160, 162, 163, 164, 165, 174, 180, 181, 193, 194, 201, 202, 209, 248, 250, 253, 270, 278, 279, 281
 — Adriatic, 25
 — African, 46, 88, 93, 100, 155
 — American, 47
 — Basket, 30, 103
 — Black, 33
 — Botany Bay, 47
 — Brown, 25, 108
 — Californian Live, 21, 103
 — Canadian, 47
 — Ceylon, 90
 — Chestnut, 46
 — Chinquapin, 46, 103
 — Coast, She, 86

- Oak, Cork, 178, 253
 — Cow, 30
 — Evergreen, 174
 — Forest, 46, 112
 — Indian, 21, 72, 73, 108
 — Iron, 25
 — Kermes, 25, 112
 — Levant, 25
 — Live, 103
 — Maul, 21
 — Mossy-cupped, 25
 — Mountain, 46
 — Quercitron, 33
 — River, 47, 86
 — Salt Water Swamp, 86
 — Scrubby, 85
 — She, 47, 112, 218, 220, 221
 — Shingle, 47, 86, 112
 — Silky, 47, 112, 166, 215
 — Silvery, 47
 — Swamp Chestnut, 30
 — Thick Cup Live, 21
 — Turkey, 25, 37, 47, 108, 112
 — Valparaiso, 21
 — Yellow, 32, 46, 103
 — Wainscot, 25
 — Zeen, 30, 65, 79, 100
 Oblique grain, 271
Ocotea bullata, 101
Odina Wodier, 90, 108
 Odum, 78
 Oil, Eucalyptus, 166
Oldfieldia africana, 93, 101
Olea Cunninghamii, 92, 112
 — *europaea*, 86, 114
 — *laurifolia*, 100
 — *verrucosa*, 47
Olearia argophylla, 85
Olinia cymosa, var. *intermedia*, 59
 Olive, 86
 — Native, 10, 84
 Olive, Spurious, 84
 — Wild, 47
 Onion Bay, 34
 Orange Wood, 32, 59
Orchestes fagi, 121
Orygia antiqua, 121
 Osage, Orange, 21, 61, 86, 92, 103
 Osier, 120, 252
 — Golden, 27
 — Stag's Head, 17
Osyris compressa, 213
 Otara, 221
Ougeinia Dalbergioides, 48, 109
Owenia venosa, 14, 113
 Pacara, 8, 48, 105
 Pader, 8, 48, 108
 Padouk, 38, 48, 108, 165, 215
 Padri, 48
 Pai Cha, 35, 108
 Palisander Wood, 59, 105
 Panacoco, 13, 37, 105
 Pannage, 162
 Paper-bark tree, 19
 Paper-bark Tea Tree, 19
 Paper pulp, 232
Paulownia, 52
 — *acuminata*, 52
 — *imperialis*, 108
 Paving, 60
 Pear, 14, 86, 108, 114, 126, 133, 144, 250
 — Hard, 59, 100
 — Red, 28, 92, 100
 — Thorn, 28
 — White, 86, 93, 100
 — Wit, 86
 — Wolf, 28
Pentace burmanica, 49, 109
 Peppermint, 62, 77
 — Bastard, 64, 78
Periblem, 262

- Peridermium pini*, 151
 Persea, 4
 Persimmon, 279
 Peruvian Bark, 56
 Pests, Fungoid, 139
 — Insect, 116
Peziza Willkommii, 148
 Phloem, 263
Phoradendron flavescens, 149
Phyllocladus trichomanoides, 80
Phyllodecta vitellinæ, 120
Physocallyma scaberrimum, 53, 113
Picea excelsa, 26, 68, 115
 — *nigra*, 68
 — *rubra*, 68, 104
 — *sitchensis*, 26, 104
Picraneæ excelsa, 56, 105
 Piles, 62
 Pin bush, 97, 109
 Pine, Aleppo, 180, 212
 — American, 125, 127
 — Bast beetle, 133
 — Black, 14, 63, 65, 86, 112, 221
 — Blister, 151
 — Broom, 55
 — Brown, 55
 — Bull, 199
 — Bunya, 83
 — Canadian Red, 155
 — Canary Island, 212
 — Celery-leaved, 80
 — Celery-topped, 80
 — Cluster, 25, 56, 114
 — Columbian, 30
 — Common, 63
 — Cowdie, 79
 — Cuban, 200
 — Cypress, 43, 63, 77, 200
 — — Mountain, 12
 — Dark, 63
 — Douglas, 54
 — Pine, Dundatha, 14, 112
 — Georgia, 55
 — — Yellow, 200
 — Ginger, 70
 — Great Sugar, 30
 — Hard, 55
 — Hazel, 44
 — Hickory, 25, 103
 — Hoop, 14
 — Kahikatea, 222
 — Kauri, 79, 166, 212, 214, 221
 — King William, 42
 — Lachlan, 63
 — Loblolly, 200
 — Long-leaf, 14, 25, 37, 55, 103, 200
 — — Yellow, 55
 — Long Straw, 55
 — Maritime, 56, 174, 176, 180, 212
 — Matai, 222
 — Monterey, 212
 — Moreton Bay, 14, 73, 112
 — Murray, 63
 — Murrumbidgee, 63
 — New Zealand, 79
 — North Carolina, 30
 — Northern, 8, 14, 115, 118, 120, 121, 122, 125, 127, 131, 132, 133, 147, 155, 162, 163, 164, 174, 175, 181, 193, 196, 199, 200, 206, 208, 211, 212, 232, 247
 — Oregon, 9, 103, 122, 200, 204, 205, 211
 — Otara, 221
 — Pensacola, 55
 — Pitch, 25, 55, 79, 103, 155, 163, 164, 165, 200, 212
 — Pumpkin, 30

- Pine, Red, 54, 55, 160, 200,
205, 208, 221
— Rimu, 221
— Sawfly, 121
— Sea, 56
— Short-leaf, 200
— Slash, 200
— Silver, 79, 112, 222
— Southern, 55
— Stringy-bark, 12
— Sugar, 14, 30, 103, 199,
200
— Swamp, 55
— Swiss, 67, 68
— Table Mountain, 25
— Turpentine, 55
— Virginia, 200
— Weevil, 131
— Westland, 65, 222
— Weymouth, 9, 127
— White, 9, 30, 63, 103, 163,
164, 165, 199, 200, 207,
208, 211, 222, 238, 279
— — Bastard, 30
— Yellow, 9, 54, 55
Pinus Lambertiana, 103
— *longifolia*, 24, 107
— *palustris*, 55, 103
— *pinaster*, 55, 114
— *pungens*, 25, 103
— *rigida*, 25, 103
— *strobus*, 9, 103, 151
— *sylvestris*, 8, 114
Piptadenia cebil, 88, 104
— *rigida*, 82, 104
Pissodes notatus, 131
— *pini*, 131
Pistachia terebinthus, 57, 165
Pitch Pockets, 157
Pith rays, 264
Pits, 274
Pityogenes bidentatus, 132
Plane, 31
— American, 31
Plane, Eastern, 14, 48, 86,
114, 250
— Occidental, 31
— Western, 31, 103
Plataan, 31
Platanus occidentalis, 31,
103, 114
— *orientalis*, 14
Platylophus trifolius, 39, 99
Platypodidæ, 136
Plerome, 262
Plum, 15, 17, 59, 86, 103,
109, 112, 115, 126, 133,
141, 279
— Acacia, 17
— Sebastan, 73, 100, 109
— Sour, 15, 112
— White, 84
Podocarpus, 3
— *Thunbergii*, 38, 101
— *Totara*, 66, 113
Polyporus, 141, 144, 145,
146, 147, 148
— *borealis*, 144
— *dryadens*, 144, 146
— *fulvus*, 144, 146
— *ignarius*, 144, 146
— *sulphureus*, 144, 146
— *vaporarius*, 144, 151
Poplar, 10, 11, 67, 68, 118,
120, 130, 131, 134, 135,
144, 164, 180, 200, 232,
243, 250, 272, 278, 279
— American, 242
— Balsam, 67, 103
— Black, 21, 38, 103
— — Italian, 67
— Carolina, 11, 67
— Large-toothed, 68, 103
— leaf beetle, 120
— Longicorns, 130
— Necklace, 11, 67
— Red, 77
— Swiss, 67

328 TIMBERS AND THEIR USES

- Poplar, Virginian, 10
 — White, 77
 — Yellow, 10
 Poppy tree, 49
 Popular names, 3
Populus balsamifera, 67, 105
 — *grandidentata*, 68, 103
 — *monilifera*, 11, 67, 103
 — *tremula*, 66, 95, 113
 — *tremuloides*, 66, 101
 Porcupine Wood, 97, 109
 Portia tree, 49
 Powellizing, 290
 Prickwood, 24
 Pride of India, 40
 Prince Wood, 12
 Procambium, 263, 267
Prosopis juliflora, 45, 103
 — *spicigera*, 90
 Protection forests, 197
 Protoxylem, 267
Prumnopitys spicata, 65, 112
Prunus cerasus, 96, 102, 114
 — *domestica*, 59, 103, 109, 112
 — *serotina*, 11, 102
 — *spinosa*, 95, 113
Pseudotsuga, 3
 — *Douglassi*, 54, 103
Pterocarpus erinaceus, 100
 — *indicus*, 38, 108
 — *marsupium*, 9, 109
 — *santalinus*, 33, 109
Pterocelastrus rostratus, 100
Pteroxylon utile, 5, 100
Puccinia fraxini, 151
 Pulp, Bleaching, 241
 — Brown mechanical, 236
 — Cold ground, 236
 — Easy-bleaching, 241, 243
 — Hot-ground, 236
 — Leather board, 236
 — Strong, 241, 243
 Puriri, 65, 80, 113
 Purpleheart, 9, 48, 105
Pygaera bucephala, 123
 Pypgrass, 213
Pyrus, 272
 — *aucuparia*, 22, 103, 109, 115
 — *communis*, 86, 108, 114
 — *malus*, 82, 101, 106, 113
 — *rivularis*, 50, 101
 — *tomentalis*, 115
Qualea caerulea, 54
 Quar, 48
 Quassia, 56, 105
 Queenwood, 15, 82
 Quickbeam, 27
 Quick Tree, 27
 Quicken Tree, 22
 Quinine, 56, 105
Quercus acuta, 17, 106
 — *cerris*, 25, 108, 114
 — *chrysolepis*, 21
 — *coccifera*, 25, 114
 — *Mibeckii*, 30
 — *Michauxii*, 30
 — *Muhlenbergii*, 46
 — *robur*, 65, 114
 — *rubra*, 47
 — *semicarpifolia*, 25, 108
 — *suber*, 253
 — *tinctoria*, 32
 — *virens*, 92
 Rata, 80, 113, 222
 — Northern, 73
 Rays, Medullary, 264, 265
 — Pith, 264
 Red Heart Rot, 144
 Redwood, 15, 38, 48, 199, 201
 — Californian, 15, 103
 Resin, Damar, 165
 — Pockets, 157
 Rewa-rewa, 15, 53, 113

- Rhamnus catharticus*, 83, 99,
 106, 114
 — *frangula*, 23, 99, 106, 114
 — *purshiana*, 54, 101
 Rhodes, Bois de, 12
 Rhododendron, 151
Rhus Thunbergii, 59, 100
Rhynchota, 125
Rhytisma, 150
 Ribbon Wood, 44
 Rift-sawn timber, 285
 Rimu, 15, 37, 48, 113
 Rings, Annual, 267, 268, 270
 Ring shakes, 156
Robinia panacoco, 13, 105
 — *pseudacacia*, 91, 102, 114,
 279
 Roses, Bois de, 12
 Rosewood, 34, 95, 100, 105,
 200
 — Australian, 73, 113
 — Bastard, 16, 73
 — Brazilian, 16, 33, 48, 60,
 86
 — Burmese, 38
 — Canary, 57, 100
 — Dominica, 12
 — Native, 49
 — Red, 31
 Rot, Dry, 151
 Rot, Heart, 147
 Rowan, 86, 103, 109, 115
 Rubber, 57, 106
 Russia, Forestry in, 198
 Rust, 150, 151
Rymandra excelsa, 113

 Sabicu, 48, 73, 106, 155
 Saddle tree, 10
 Safforan, 48
 Saffron, 48
 — -hout, 48
 — Wood, 21, 48, 100
 Saj, 21, 62, 73, 109
 Sal, 5, 28, 80, 109
 — Morung, 80
 Saliehout, 35
 Saliewood, 28, 35, 100
Salix alba, 97, 101, 109, 115
 — *fragilis*, 17, 109, 115
 — *nigra*, 26, 104
 — *triandra*, 252
 — *viminalis*, 252
 — *vitellina*, 26, 115
 Sally, Black, 58
 Sandal, 280
 — Babal, 215
 Sandalwood, Indian, 20, 57,
 109, 165
 — Red, 33
 Sandan, 48, 93, 109
 Sanders Wood, Red, 16, 109,
 165, 215
Sandoricum indicum, 20, 108
Santalum album, 57, 109
Saperda carcharias, 130
 — *populnea*, 130
 Sapodilla Wood, 49, 106
 Sappan, 109
 Sapwood, 270, 272, 287, 283
Sartage, 172
 Sassafras, 29
 — Assam, 11
 — Cayenne, 49
 Satinwood, 16, 106
 — West Indian, 49
 Saul, 80
 Sawflies, 121, 122
 — Pine, 121
 Scale, Brown, 126, 127
 — Mussel, 126, 127
 — Willow, 126
Schleichera trijuga, 90, 108
 Schools, Forestry, in Austria,
 194
 — — — France, 168
 — — — Germany, 185
 — — — Italy, 191

330 TIMBERS AND THEIR USES

- Schools, Forestry, in Switzer-
 land, 188
Scolopia Ecklonii, 100
 — *Mundtii*, 28, 92
Scolytidæ, 132
Scolytus destructor, 133
 — *intricatus*, 133
 — *pruni*, 133
 Seasoning, Artificial, 289
Sequoia, 279
 — *sempervirens*, 15
 Service, 28, 35, 86, 115
 — Tree, Fowler's, 22
Sesia bembiciformis, 135
 Shakes, 155
 — Heart, 286
 — Ring, 156
 — Star, 156
 Shingle Wood, 29
 Shipbuilding, 68
 Shipworm, 137, 138
 Shittim Wood, 54
Shorea robusta, 80, 109
Sideroxylon australe, 110
 — *inermis*, 5, 71, 100
 Sieve plates, 274
 — tubes, 274
 Sihewald, 189
 Silk bark, 49, 86, 100
 Silver grain, 270
 Silvertop, 43
 Silver Tree, 65
Siphonodon australe, 35, 111
 Sipiera, 63
 Sipiri, 63
Siricidæ, 137
 Siris, Pink, 49, 73, 100, 109
 Sirissa, 49
 Siris Tree, 10
 Sirsa, 49
 Siruaballi, Yellow, 42
 Sissoo, 49, 93, 109, 215
 Sleepers, 74
 Sloe, 95
 Sneezewood, 2, 5, 8, 16, 49,
 100
 Sonari, 73
Sophora japonica, 33, 109
 — *tetraptera*, 28, 112
Sorbus domestica, 35
Soymida, 4
 — *febrifuga*, 71, 108
 Specific gravity, 296
 Spindle tree, 25, 100, 109,
 115
 Spiral grain, 157
 Spruce, 26, 60, 68, 118, 127,
 128, 132, 133, 134, 163,
 165, 174, 181, 199, 200,
 204, 205, 206, 208, 210,
 211, 212, 214, 238, 278
 — American, 68
 — Black, 26, 60, 68, 103
 — Californian Coast, 26
 — Canadian, 68
 — Common, 26
 — Double, 68
 — Douglas, 54
 — Englemann's, 211
 — Hemlock, 78, 208
 — Menzies, 26
 — Muskeg, 68
 — New Brunswick, 68
 — Norway, 26, 68, 196
 — Red, 26, 68, 80, 104
 — Russian, 26
 — rust, 151
 — St. John's, 68
 — Silk, 26
 — Sitka, 9, 26, 37, 73, 104
 — Tide-land, 26
 — White, 196
 Stavewood, Black, 65
 Stele, 266
Stenocarpus salignus, 47,
 112
Stereospermum chelonoides,
 48, 108

- Stinkwood, 9, 21, 49, 101, 280
 — Cannibal, 9
 — Red, 82
 Stonewood, 65
 Strawberry tree, 24
 Stringybark, 37, 38, 43, 49, 66, 93, 113, 218, 219, 220
 — Gum-top, 20
 — Red, 65
Stryphnodendron guianense, 12, 105
 Sugarberry, 89
 Sugar Tree, 45, 72
 Sugi, 53, 109
 Sumach, 165
 — Cape, 213
 Sundri, 5, 93, 109
 Sweden, Forestry in, 196
 Swietenia, 4
 Switch Sorrel, 35, 106, 109
 Switzerland, Forestry in, 187
 Sycamore, 31, 104, 115, 119, 124, 126, 135, 150, 202, 203, 250, 278
Syncarpia laurifolia, 66, 113
Synoum glandulosum, 16, 73, 113
Syzygium Jambolana, 79, 108, 112

Tabebuia flavesceus, 79, 105
 Tacamahac, 67
 Tallow Wood, 62, 66, 93, 113, 164, 215, 220
 Tamarack, 80, 81, 104, 165, 209
 — Western, 49
 Tamarind, 26, 87, 98, 101, 106, 109
Tamarindus indica, 26, 101, 106, 109
 Tamkaha, 54, 66, 80, 113

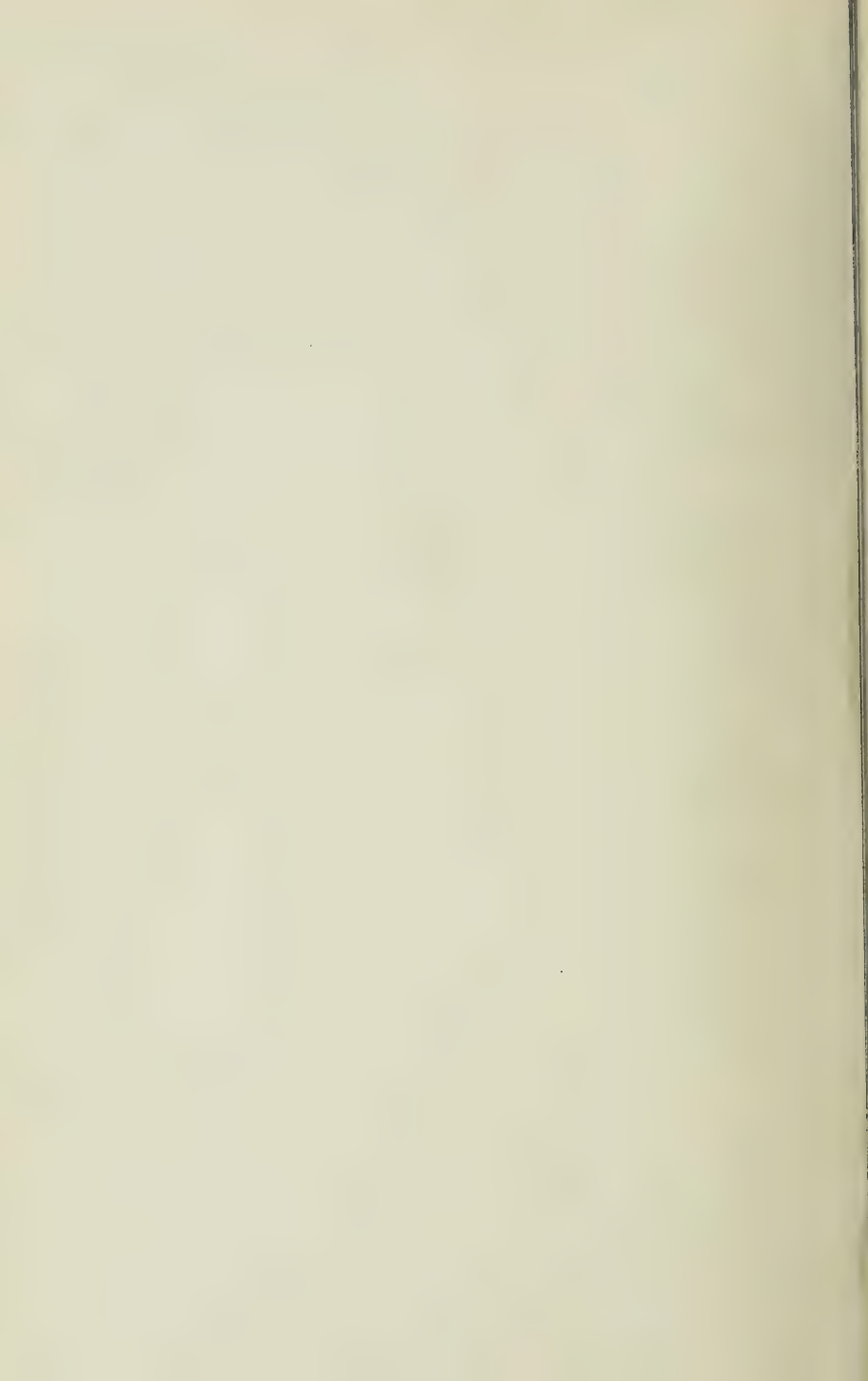
 Tanning, 248
 Tarco, 16, 106
Tarrietia argyrodendron, 65
 Tar spot fungus, 150
Taxodium distichum, 76, 102
Taxus baccata, 109
 Teak, 69, 73, 78, 115, 155, 163, 164, 165, 215, 279, 280, 281, 286
 — African, 93, 101
 — Bastard, 9, 21, 49, 74, 109
 — New Zealand, 80
 Tea Tree, 77
 — — Paper-barked, 19
 — — Swamp, 19
 — — White, 19
Tecoma leucoxydon, 41, 104
 — *pentaphylla*, 63, 104
Tectona grandis, 73
 Tee, 62
 Telegraph Poles, 81
 Terebinth, 57, 115
Teredo naualis, 137
Terminalia acuminata, 71, 105
 — *Arjuna*, 53
 — *Chebula*, 32, 107
 — *tomentosa*, 62, 109
 Termites, 135, 136, 137
 Testing, 292
 Tests, Compression, 299
 — Density, 295
 — Hardness, 305
 — Moisture, 294
Tetraclinus articulata, 101
 Tewart, 74
Thespesia populnea, 109
 Thitka, 49, 109
 Thorn, 28, 92
 — Pear, 28
 Thorny Jack, 70
Thouinia Weinmannifolia, 16, 106

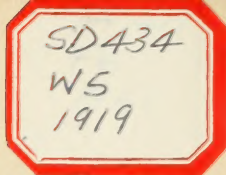
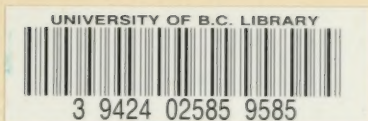
332 TIMBERS AND THEIR USES

- Thujaopsis dolabrata*, 5
Thuya, 9, 101, 180
 — *articulata*, 9
 — *gigantea*, 29
 — *gigantissima*, 102]
Tilia americana, 29, 95
 Toadstool, Yellow, 146
 Tonka Bean, 49, 57
 Tonquin Bean, 57, 87, 106
 Tooart, 66, 74, 113, 155,
 217, 301, 302
 Toon, 41, 215, 280
 Torchwood, Mountain, 43
Torreya nucifera, 13, 108
 Torse Wood, 158
Tortricidæ, 124
 Tortrix, Green, 124
 — Pine Shoot, 125
 Totara, 66, 81
 Towai, 62
 Towhai, 62
 Trade names, 3
Trametes pini, 147
 — *radiciperda*, 147
 Tree of Heaven, 26, 109
 Trefoil, Bean, 9
Tristania, 4
 — *conferta*, 69, 110
 — *maculata*, 61
 — *neriifolia*, 27
 — *suaveolens*, 64, 78
Trochocarpa laurina, 82, 110
Trypodendron, 133
 — *domesticum*, 133
 — *lineatum*, 133
Tsuga canadensis, 78, 102
 Tuart, 74, 217
 Tulip tree, 10, 21, 49, 74, 87,
 104
 — Wood, 15, 16, 36, 53, 106,
 113, 220
 — — Bahia, 53
 Tupelo, 16
 Turnip Wood, 16, 113
- Turpentine tree, 62, 66, 77,
 81, 91, 113, 202
Ulmus americana, 30, 102
 — *campestris*, 19, 114
 — *effusa*, 84, 114
 — *fulva*, 70, 102
 — *montana*, 70, 114
 — *racemosa*, 19, 102
 Umber, Mottled Moth, 124
 Umbrella tree, 4, 9, 74,
 109
 Uredinæ, 150
 Valonia, 165
 Vapourer Moth, 123
Vateria indica, 56, 109
 Violet Wood, 96
 Violin Wood, 68
 Virgin Cork, 254
Vitex altissima, 8, 105
 — *littoralis*, 80, 113
 Vlier, 87, 101
 Wacapou, 16, 74, 81
 Walnut, 60, 162, 164, 278,
 279
 — American, 17, 93, 104
 — Auvergne, 69
 — Black, 17, 93, 202
 — Cape, 9
 — Circassian, 60
 — East Indian, 10, 50, 93,
 101, 109
 — English, 60
 — European, 17, 60
 — Italian, 60
 — Satin, 16, 45
 — Waney Black, 17
 Wandoo, 81, 113, 301, 302
 Wasp's Wood, 137
 Water tree, 97
 Wattle, 212, 213, 219, 220
 — Bark, 165

- Wattle, Black, 212, 213
 — Broad-leaved, 215
 — Cyclopis, 213, 218
 — Feather-leaved Black, 215
 — Golden, 213
 — Silver, 213
 Weevils, 120
 — Pine, 131
 Wheels, 87
 White Ants, 135, 137
 — Sally, 17
 Whitethorn, 35, 279
 Whitewood, 10, 67, 68
 — Canadian, 10
 — Canary, 10, 279
 Willow, 29, 130, 131, 134, 135, 144, 250, 252, 253, 272, 279
 — Beetle, 120
 — Black, 26, 104
 — Crack, 17, 74, 109, 115
 — Goat, 120, 135
 — Redwood, 17
 — White, 97, 109, 115
 — Yellow, 27, 115
 Winter-felled timber, 282
 — Moth, 124
 Withy, 17
 Witness, 236
 Wood, Formation of, 257
 Wood Leopard Moth, 135
 Woolly Butt, 77, 93, 113
Xestobium domesticum, 137
 — *tessellatum*, 137
Xyleborus dispar, 133
 Xylem, 263
Xylia dolabriformis, 62, 104, 106
Xylocarpus granatum, 88, 107
Xylocopa, 137
 Yate, 301
 Yellow Wood, 10, 49
 — — Light, 71
 — — Real, 101
 — — Upright, 38
 Yen Dike, 94, 109
 Yenu, 33, 109
 Yew, 109, 250, 258, 279
 — New Zealand, 66
Zanthoxylum capense, 90, 100
 Zapatero, 63
 Zebra Wood, 50, 106
Zelkova, 50, 115
 — *acuminata*, 52, 108
 — *crenata*, 50, 115
Zeuzera aesculi, 135
 Zybast, 87

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